FULL STUDY PLAN FOR VERTEBRATE AND VASCULAR PLANT INVENTORY OF THE CHIHUAHUAN DESERT NETWORK

Amistad National Recreation Area, Texas
Big Bend National Park, Texas
Carlsbad Caverns National Park, New Mexico
Fort Davis National Historic Site, Texas
Guadalupe Mountains National Park, Texas
White Sands National Monument, New Mexico

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I. INTRODUCTION

A. Biological Inventory Background

Since 1916, the stated mission of the National Park Service (NPS) has been to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations (National Park Service 1988). However, throughout its history, the NPS has emphasized public use and enjoyment and landscape aesthetics, often to the detriment of natural ecosystems within the parks (National Research Council 1992; Sellars 1997).

An understanding of the diversity, distribution, and population status of species occurring within each park is essential for making informed decisions concerning management of natural resources, and to effectively manage for biodiversity. However, as of 1994, the majority of national parks surveyed did not have complete inventories of the major taxonomic groups within the National Park system (Stohlgren et al. 1995). Studies report high extinction rates of mammals (Newmark 1995), amphibians (Drost and Fellers 1996), and plants (Drayton and Primack 1996) on some land managed by the National Park Service. This has resulted in criticism of the National Park Service (Debinski and Brussard 1994, Stohlgren et al. 1995).

The need for complete and credible biological information has long been recognized (Sellars 1997). In response to this need the National Park Service initiated an Inventory and Monitoring Program in the early 1990s to conduct baseline inventories, scientific research and study long-term changes in the biological resources found in the parks (National Park Service 1992). This program largely emphasized work in 'prototype' parks that served as models for other parks in the system. In 1998, Congress appropriated service wide funding for a "program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the conditions of National Park System resources" (National Park Service 1999a). As the first step in this program, 32 networks of parks nationwide have been asked to develop detailed study plans for biological inventory. This document outlines the proposed plan for biological inventory of vertebrates and vascular plants in the Chihuahuan Desert Network (CDN).

A primary goal of the inventory project is to provide park managers in the network with scientifically sound information on the nature and status of selected biological resources in a readily accessible form to assist on-the-ground resource management. Organization of a network-based inventory and monitoring program offers several benefits through increased efficiencies in designing and conducting inventory work, and improved opportunities for exchange of ideas and information across parks.

B. Objectives

The objectives of this inventory project are as follows:

1. To document the occurrence of at least 90% of the vertebrate and vascular plant species currently estimated to occur in the Chihuahuan Desert Network parks by using verifiable historical data and targeted field investigations of random, repeatable design.

2. To provide the baseline information needed to develop a general monitoring strategy and design for vertebrates and vascular plants, which can be implemented by parks when inventories have been completed, and which is tailored to specific park threats and resource issues.

3. To describe the distribution and relative abundance of species of special concern, such as Threatened and Endangered species, exotics, and other species of special management interest occurring within park boundaries.

4. To input collected data into the appropriate NPS databases, and to develop a coordinated network data management effort that results in information concerning biological resources being easily accessible to park managers, resource managers, scientists and the public.

C. Overview of the Chihuahuan Desert Network

One of the 32 networks established by the National Park Service for the Inventory & Monitoring Program, the Chihuahuan Desert Network (CDN) includes six park units managed by the National Park Service in the states of New Mexico and Texas (Figure 1 and Table 1). These park units, ranging in size from 192 to 324,232 hectares, are all located in or within a transitional zone of the Chihuahuan Desert, one of the most biological diverse arid regions in the world.

Table 1. National Park Service Units in the Chihuahuan Desert Network

Unit	Park code	Hectares	Acres
Amistad National Recreation Area	AMIS	23,185	57,292
Big Bend National Park	BIBE	324,232	801,163
Carlsbad Caverns National Park	CAVE	18,926	46,766
Fort Davis National Historic Site	FODA	192	474
Guadalupe Mountains National Park	GUMO	35,272	86,416
White Sands National Monument	WHSA	58,169	143,733
	Total	459,976	1,135,844

Collectively, these six parks along with a sister park, Chamizal National Monument in El Paso, Texas, represent the nation’s most significant preserved natural, cultural, and recreational values in the Chihuahuan Desert landscape. While Chamizal NM is not included in this plan because of their lack of a need for biological inventories, they are nonetheless a vital component of the National Park Service representation in the Chihuahuan Desert Region. The six park units making up the Chihuahuan Desert Network (CDN) for biological inventory purposes, are each highlighted below (a more detailed description of each unit is found in Appendix A):

Amistad National Recreation Area (NRA), resulting from construction of Amistad Dam in 1969, contains 43,250 water acres and 14,042 land acres (Figure A-1). The park is located at a convergence of the Chihuahuan Desert, the Edwards Plateau Savannah, and the Tamaulipan Mezquital Ecoregions (Ricketts et al. 1999). Riparian, shoreline, inundation zone and upland desert ecosystems support terrestrial species diversity. Aquatic species occur in the lake and sections of the Devils, Rio Grande, and Pecos rivers.

Big Bend National Park (NP), established in 1944, includes 801,163 acres, and is the largest protected area representative of the Chihuahuan Desert (Figure A-2). The park is a U.S. Biosphere Reserve, includes 533,900 acres of recommended wilderness, and administers the 190-mile Rio Grande Wild and Scenic River. Species diversity is increased due to inclusion of the Rio Grande and the Chisos Mountains, a 50-square mile range that is home to numerous relict and isolated populations.

Carlsbad Caverns National Park (NP), established in 1923, includes 46,766 acres, of which 33,125 acres are Designated Wilderness (Figure A-3). World Heritage Site designation indicates the significance of the park's cave and other resources. Surface elevations range from 3,595 to 6,520 ft, and include fossilized reef uplands and diverse incised canyons.

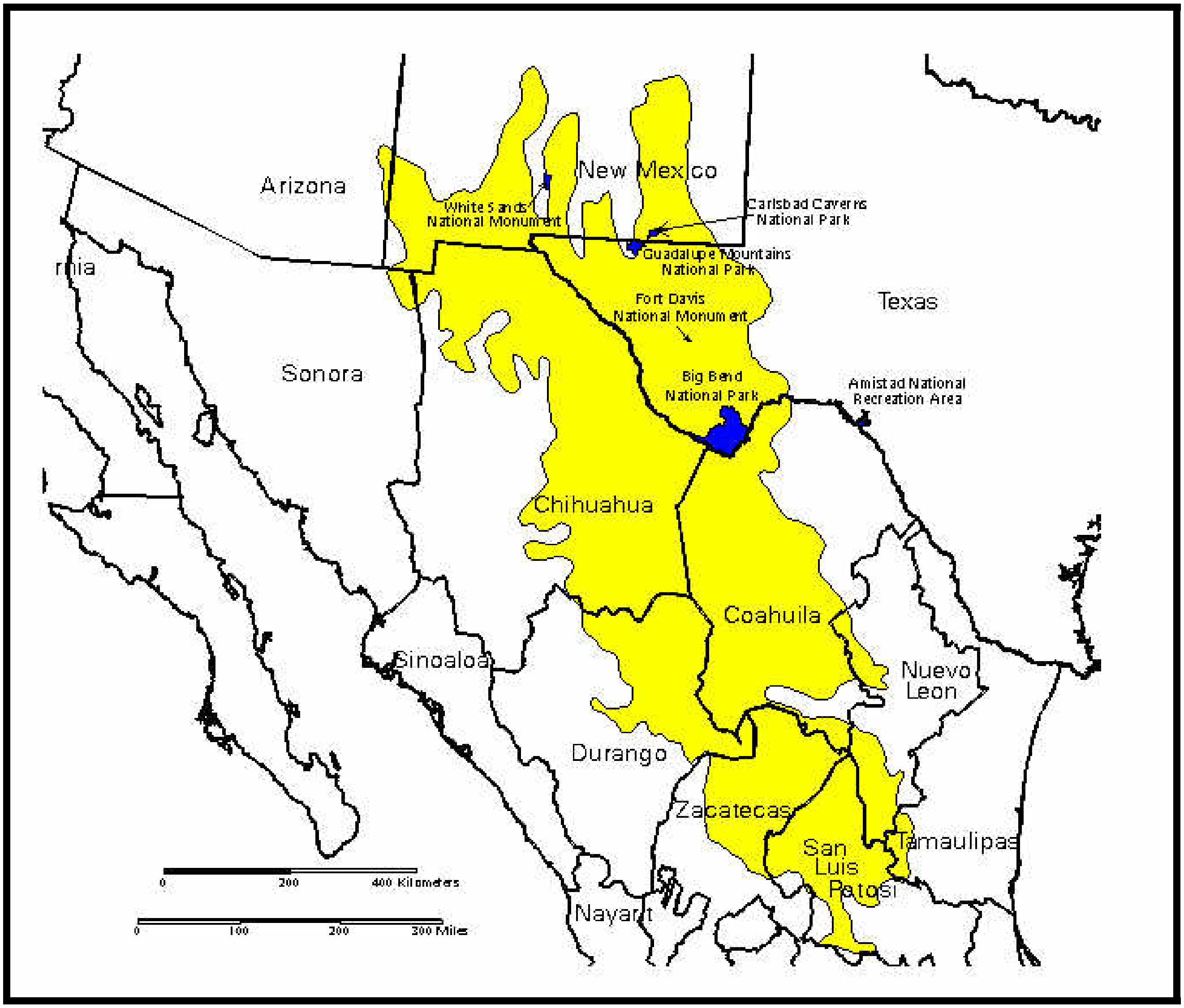
Fort Davis National Historic Site (NHS), established in 1963, is in the Davis Mountains, Texas' most extensive mountain range (Figure A-4). The 474-acre park preserves fort structures and interprets the era of westward migration and the late 19th century U.S. Army. Natural resources include a striking blend of desert, woodland, and grassland, a historic cottonwood grove, and associated faunal communities.

Guadalupe Mountains National Park (NP), established in 1972, consists of 86,416 acres, of which 46,850 are Designated Wilderness (Figure A-5). The park preserves the world's most significant fossilized reef outcrops of Permian age limestone, designated as an International Benchmark Standard for Geology, and the Chihuahuan Desert resources that occur upon it. Elevation-related environmental diversity ranges from lowland salt basin to relict conifer forests, including Texas' highest point at 8,749 feet.

White Sands National Monument (NM), established in 1933, encompasses 143,733 acres of the Tularosa Basin in south central New Mexico, and preserves approximately half of the world's largest gypsum sand dune field (Figure A-6).

Together, these six parks contain and protect unique components of Chihuahuan desert and associated habitats and vertebrate assemblages.

Figure 1. Map of the Chihuahuan Desert Network area showing Park Locations.



This map shows the locations of the six parks in the Northern Chihuahuan Desert. This map was produced from a map obtained from the World Wildlife Fund website: www.worldlife.org/global/200/).

D. Biophysical Overview of the Chihuahuan Desert

<u>The Chihuahuan Desert Ecoregion Overview:</u>

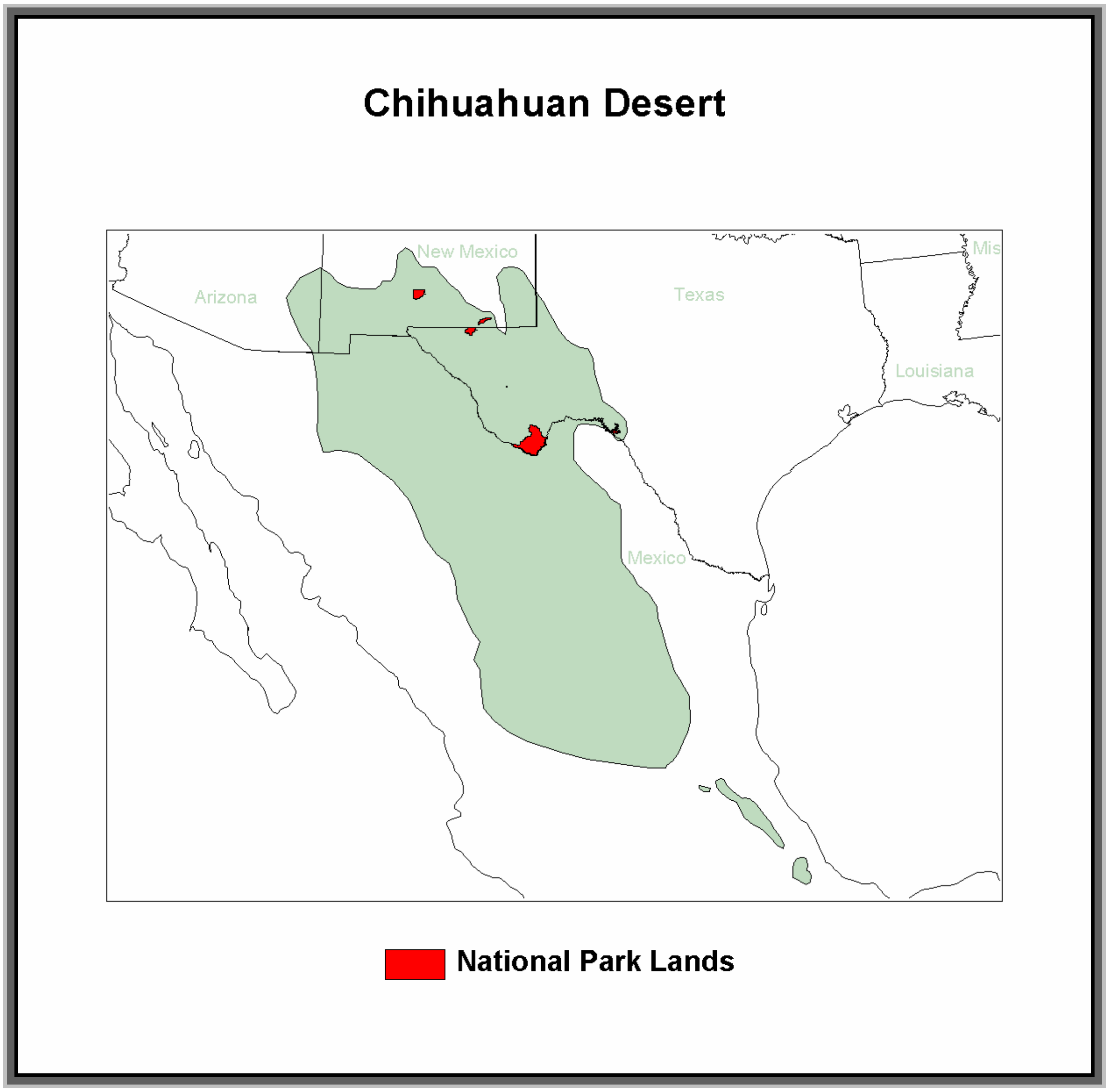
The Chihuahuan Desert (Figure 2) is the largest of the four North American deserts covering an area of approximately 629,000 sq. kilometers (243,000 square miles) (Dinerstein, et al. 2000). The Chihuahuan Desert is one of the three most biologically rich and diverse desert ecoregions in the world, rivaled only by the Great Sandy-Tanami Desert of Australia and the Namib-Karoo of Southern Africa (Olson and Dinerstein 1998). Nearly two-thirds of its total geographic area lies in Mexico, but at its northernmost extent, the desert reaches into the United States in western Texas, southern New Mexico and extreme southeastern Arizona (Powell 1998).

The landscape is a series of basins and ranges with a central highland extending from Socorro, New Mexico south into Zacatecas, Mexico. Because of its generally higher elevation, the Chihuahuan Desert is cooler and has more rainfall than other warm desert ecoregions. (Dinerstein, et al. 2000).

The Chihuahuan Desert is characterized by shrub and grassland vegetative associations and supports one of the most diverse communities in the world. Shrubs dominate the landscape of the Chihuahuan Desert, with shrub communities covering 55% of the desert; and grasslands covering an additional 20% of the desert (Dinerstein, et al. 2000). It is home to more than 470 species of terrestrial vertebrates (including five endemic reptiles), more than 100 species of cacti, and more than 30 endemic species of invertebrates (Rickets et al. 1999). Dinerstein et al. (2000) reports that the U.S. portion alone of the Chihuahuan Desert contains approximately 2263 species of vascular plants, over 100 species of mammals, over 100 species of reptiles, 250 bird species, 20-25 amphibian species and 250 butterflies; and that the levels of endemism in cacti, euphorbs, composites, legumes, grasses, and plants in the Nyctaginaceae are very high, with high replacement of species from basin to basin.

Rickets et al. (1999) classified this ecoregion as having Class I Conservation Status, considering it to be a globally outstanding region in need of immediate protection. Likewise, the World Wildlife Fund sponsored a global assessment of the Chihuahuan Desert, which identified it as one of the most important arid ecoregions on Earth (Olson and Dinerstein 1998). The World Wildlife Fund has applied an ecoregion-based conservation (ERBC) approach to meeting the conservation needs of the Chihuahuan Desert. They are partnering with many organizations, agencies, etc. in both the U.S. and Mexico to support conservation of this biologically rich ecoregion (Dinerstein et al. 2000).

Figure 2. Map of the Chihuahuan Desert Ecoregion.



About one-third of the Chihuahuan Desert Ecoregion is in the United States with the remaining two-thirds in Mexico. There are various interpretations of the boundaries of the Chihuahuan Desert, depending on the reference source. Size estimates vary from 629,000 square kilometers (Dinerstein, et al. 2000) to 722,159 square kilometers (Texas Cooperative Studies Unit calculations from the ESRI web site map). The above map is a projection of the ESRI map of the range of the Chihuahuan Desert.

Vegetative Descriptions:

Although vegetation composition varies along environmental gradients (Whittaker 1975, Crawley 1997), many ecologists delineate "vegetation communities" for purposes of descriptive convenience. In this proposal, we follow Powell (1998) in describing the Chihuahuan Desert vegetation communities that occur in the Trans-Pecos region of Texas, the southern and southeastern portions of New Mexico and the Tularosa Basin of New Mexico. We follow Hatch et al.. (1990), which is based on Gould (1975a and b), in describing both the vegetation associated with the Edwards Plateau and the South Texas Plains regions of Texas.

Powell (1998) describes five major vegetation communities that occur in the Trans-Pecos region and Northern Chihuahuan Desert Ecoregion:

Chihuahuan Desert Scrub occurs at lower elevations and is characterized by annual precipitation of 18-30 centimeters (7-12 inches). The Desert Scrub community is characterized by shrubs such as Creosotebush (*Larrea tridentata*), Catclaw Mimosa (*Mimosa aculeaticarpa biunicifera*), acacias (*Acacia* spp.), Mariola (*Parthenium incanum*), Honey Mesquite (*Prosopis glandulosa*), Fourwing Saltbush (*Atriplex canescens*), Tarbush (*Flourensia cernua*), Javelinabush (*Condalia ericoides*), Skeletonleaf Goldeneye (*Viguiera stenoloba*), Ocotillo (*Fouquieria splendens*), Allthorn (*Koeberlinia spinosa*), and semi-succulents such as Lechuguilla (*Agave lechuguilla*), sotol (*Dasylirion* spp.), and yucca (*Yucca* spp.). Common grasses include gramas (*Bouteloua* spp.), threeawns (*Aristida* spp.), tridens (*Tridens* spp.), and Fluffgrass (*Dasyochloa pulchella*).

Sub-categories of vegetation may occur within Desert Scrub in association with specific substrates. Species associated with saline substrates include Fourwing Saltbush, Alkali Sacaton (*Sporobolus airoides*), Winged Sesuvium (*Sesuvium verrucosum*), Frankenia (*Frankenia jamesii*), Pickleweed (*Allenrolfea occidentalis*), seepweed (*Suaeda* spp.), and Saltgrass (*Distichlis spicata*). Sandy soils may support species such as Honey Mesquite, Broom Psorothamnus (*Psorothamnus scoparius*), Sand Sagebrush (*Artemisia filifolia*), Harvard Oak (*Quercus harvardii*), and Plains Yucca (*Y. campestris*). Sotol-Lechuguilla and sotol-grassland associations are found growing in areas of limestone and igneous rock.

Grassland communities generally develop in areas with elevations of 1,067-1,585 meters (3,500-5,200 feet) that are characterized by annual rainfall of 25-46 centimeters (10-18 inches) and richer, deeper soils. Grasslands were historically widespread, but drought and soil erosion exacerbated by a history of overgrazing resulted in a gradual invasion by the Desert Scrub community, which now dominates more than half the Trans-Pecos region. Today, marginal Grassland communities may support shrubs such as prickly pear (*Opuntia* spp.), Cane Cholla (*O. imbricata*), Soaptree Yucca, Spanish Dagger (*Y. torreyi*), broomweed (*Gutierrezia* spp.), sacahuiste (*Nolina* spp.), sotol, and Honey Mesquite. Pure grassland, such as that found in the Davis Mountains, tends to be dominated by Blue Grama (*B. gracilis*). In other grassland areas, Blue Grama may be intermixed with other gramas, Tobosa Grass (*Hilaria mutica*), needlegrass (*Stipa* spp.), bluestems (*Bothriochloa* spp., *Schizachyrium* spp.), Burrograss (*Scleropogon brevifolius*), threeawns, and tridens. Tobosa Grass may be dominant at lower elevations in areas where water accumulates.

Oak-Juniper-Pinyon Woodland is characteristic of middle elevations receiving more than 38 centimeters (15 inches) of precipitation annually, and intermixes with Grassland at the upper elevation range of that community. Denser woodland may be found on north and east slopes and in protected areas, while south and west slopes support more open woodland. In the southeast Trans-Pecos a pinyon-juniper association dominated by Red-berry Juniper (*Juniperus pinchotii*) and Papershell Pinyon (*Pinus remota*) occurs between 975-1,524 meters (3,200-5,000 feet). In the Davis Mountains, oak-juniper associations occur at elevations of 1,341-1,676 meters (4,400-5,500 feet) and include Gray Oak (*Q. grisea*), Emory Oak (*Q. emoryi*), Rose-fruited Juniper (*J. coahuilensis*), and Red-berry Juniper. A pinyon-oak-juniper association occurs at elevations of 1,676-2,286 meters (5,500-7,500 feet). At the higher elevations, Alligator Juniper (*J. deppeana*) replaces other junipers, and dominant pine species include Mexican (*P. cembroides*) or Colorado (*P. edulis*) Pinyon. Other species include Gray, Emory, and Silverleaf (*Q. hypoleucoides*) Oak, needlegrass, muhlys, Bulb Panicum (*Panicum bulbosum*), and Pinyon Ricegrass (*Piptochaetium fimbriatum*). Texas Madrone (*Arbutus xalapensis*), Chisos Red Oak (*Q. gravesii*), and Bigtooth Maple (*Acer grandidentatum*) are locally common in moist areas.

Conifer Forest occurs at high elevations in the Guadalupe, Davis, and Chisos Mountains, and is suspected to be the remnant of pre-historically widespread forests. These forests are characterized by Douglas-Fir (*Pseudotsuga menziesii*), Quaking Aspen (*P. tremuloides*), Ponderosa Pine (*P. ponderosa*), Southwestern White Pine (*P. strobiformis*), *P. arizonica*, and Chinkapin Oak (*Q. muehlenbergii*). Douglas-Fir is not found in the Davis Mountains, while Quaking Aspen is rare in both the Davis and the Chisos Mountains. The Chisos Mountains lack Ponderosa Pine but support Arizona Cypress (*Cupressus arizonica*). Other plants that commonly occur in this vegetation community include Birchleaf Buckthorn (*Rhamnus betulifolia*), snowberry (*Symphoricarpos* spp.), and needlegrass.

Riparian Communities are restricted to the major and minor river systems and the drainage systems of canyons and washes associated with the mountains. Non-native salt cedars (*Tamarix* spp.) create dense stands along the Pecos River and some parts of the Rio Grande. Honey Mesquite and Desert Willow (*Chilopsis linearis*) are also common along the rivers and the Rio Grande corridor also includes Screwbean (*P. pubescens*), Rio Grande Cottonwood, willows (*Salix* spp.), Common Reed (*Phragmites australis*), and Giantreed (*Arundo doxax*).

Riparian corridors in the mountain ranges may contain oaks, cottonwoods, willows, Little Walnut (*Juglans microcarpa*), Texas Madrone, Bigtooth Maple, Velvet Ash (*Fraxinus velutina*), Netleaf Hackberry (*Celtis laevigata reticulata*), and Seepwill Baccharis (*Baccharis salicifolia*).

Tularosa Basin**:** The Tularosa Basin also supports Chihuahuan Desert Scrub vegetation, with species including Soaptree Yucca (*Y. elata*), Claretcup Cactus (*Echinocereus triglochidiatus*), Buffalo Gourd (*Cucurbita foetidissima*), Skunkbrush Sumac (*Rhus aromatica*), Frankenia, and Fourwing Saltbush. Rio Grande Cottonwoods (*Populus deltoids wislizeni*) occur in the dunes of the Tularosa Basin found in White Sands National Monument, along what is speculated to be a sub-surface water source connecting Lake Lucero to the Lost River in the northeast corner of the National Monument. Species specifically associated with the gypsum substrate of the basin include Gyp Moonpod (*Selinocarpus lanceolatus*), Gypnama (*Nama carnosum*), Gyp Grama (*), Hoary Rosemarymint (*Poliomintha incana*), Mormon Tea (*Ephedra torreyana*), and Gypgrass (*Sporobolus nealleyi*).

The Transitional Zone: Live Oak (*Q.virginia*), Harvard Oak, Post Oak (*Q. stellata*), mesquite, and juniper are common woody species of the Edwards Plateau. In overgrazed areas the dominant forbs may include Bitterweed (*Hymenoxys odorata*), Broadleaf Milkweed (*Asclepias latifolia*), Smallhead Sneezeweed (*Helenium microcephalum*), broomweed, Prairie Coneflower (*Ratibida columnifera*), Mealycup Sage (*Salvia farinacea farinaca*), Tasajillo (*O. leptocaulis*), and pricklypear. Healthier rangeland may support dense stands of Tobosa Grass intermixed with Burrograss. Other grass species include bluestems, gramas, Common Curlymesquite (*H. belangeri*), Buffalograss (*Buchloe dactyloides*), Fall Witchgrass (*Leptoloma cognatum cognatum*), and tridens. Common forbs include Engelmann Daisy (*Engelmannia pinnatifida*), *Zexmania hispida*, bush sunflower (*Simsia* spp.), Western Ragweed (*Ambrosia psilostachya*), and sneezeweed (*Helenium sp*.) (Hatch et al.. 1990).

Hatch et al.. (1990) describe the South Texas Plains as the western extension of the Gulf Coastal Plains, characterized by level to rolling topography, and upland soils that may be clayey, loamy to sandy, or predominantly loamy in structure. Elevation ranges from sea level near the Gulf Coast, to approximately 300 meters (1,000 feet) near the northern boundary, and precipitation increases from west to east. The Rio Grande originally formed a broad, meandering floodplain through this region, but most of the floodplain has been cleared for agriculture, grazing, and development (Ricketts et al.. 1999). Ricketts et al.. (1999) assign the Tamaulipan Ecoregion of the South Texas Plains a Class 2 Conservation Status, and report over six hundred species of plants and animals (including two endemic trees) as being associated with it.

The original vegetation community of the South Texas Plains was characterized by grassland or savannah along the coastal areas and brushy chaparral-grassland in the uplands, but grazing and fire suppression have contributed to the invasion by woody species such as mesquite, Live Oak, acacia, Brazil (*Zizyphus obovata*), Spiny Hackberry (*C. pallida*), Whitebrush (*Aloysia gratissima*), Lime Pricklyash (*Zanthoxylum fagara*), Texas Persimmon (*Diospyros texana*), Shrubby Blue Sage (*S. ballotiflora*), and Lotebush (*Z. obtusifolia*) (Hatch et al.. 1990).

The dominant grasses on the clay and clay loams are Silver Bluestem (*B. saccharoides torreyana*), Arizona Cottontop (*Digitaria californica*), Buffalograss, Common Curlymesquite, gramas, and *Setaria* and *Pappophorum* species. Grasses of the oak savannahs are mainly Little Bluestem (*S. scoparium frequens*), Indiangrass (*Sorghastrum nutans*), Switchgrass (*Panicum virgatum*), Crinkleawn (*Trachypogon secundus*), and *Paspalum* spp. Introduced tropical Buffelgrass (*Cenchrus ciliaris*) has proliferated and is common on loamy to sandy soils in the western half of the area. Non-natives such as Bermudagrass (*Cynodon dactylon*), Kleingrass (*Panicum coloratum*), and Rhodesgrass (*Chloris gayana*) are also common in some areas (Hatch et al.. 1990).

Pricklypear is characteristic throughout most of the area, and other forbs may include Orange Zexmania, bush sunflower, Velvet Bundleflower (*Desmanthus velutinus*), tallowweeds (*Plantago* spp.), lazy daisies (*Aphanostephyus* spp.), Texas croton (*Croton texensis*), Western Ragweed, Shrubby Oxalis (*Oxalis berlandieri*), White Milkwort (*Polygala alba*), American

Snoutbean (*Rhynchosia americana*), and Greenthread (*Thelesperma nuecense*) (Hatch et al.. 1990).

Vertebrate Descriptions:

There is an incredibly diverse range of habitats in the Chihuahuan Desert, which provides for the rich bio-diversity of the region. Vast grasslands provide habitat for critical species like burrowing owls (*Athene cunicularia*) and critical keystone species like the black-tailed prairie dogs (*Cynomys ludovicianus*) that are rapidly disappearing. Mountains form sky islands rising abruptly from these grasslands providing a home to a unique mix of desert and montane plant and animal species. These sky islands support relatively intact floristic assemblages, in an often relict environment, where a high degree of localized endemism commonly occurs due to the basin and range physiography promoting isolation. Springs, cienegas, and wetland areas, including desert playas, all combine to provide a rich mixture of habitats. Wind-blown gypsum soils form dunescapes of white sand, a rare and inhospitable habitat type that has given rise to plant species found nowhere else. (Dinerstein et al.. 2000).

The Chihuahuan Desert supports a large number of wide-ranging mammals, such as the pronghorn (*Antilocapra americana*), jaguar (*Panthera onca*), mountain lion (*Puma concolor*), and collared peccary or javelina (*Dicotyles tajacu*). Rodent species are abundant with kangaroo rats (*Dipodomys spp*.), pocket mice (*Perognathus spp*.), woodrats (*Neotoma spp*.) and deer mice (*Peromyscus spp*.) among the most important in contributing to overall structure and function of the ecosystem. Common bird species include the greater roadrunner (*Geococcyx californianus*), curve-billed thrasher (*Toxostoma curvirostra*), scaled quail (*Callipepla squamata*), and Scott's oriole (*Icterus parisorum*). Numerous raptors inhabit the desert and include Swainson's hawk (*Buteo swainsonii*), great horned owl (*Bubo virginianus*), the rare aplomado falcon (*Falco femoralis*) and zone-tailed hawk (*Buteo albonotatus*). (Dinerstien et al. 2000).

The Rio Grande, fed by its major tributaries the Pecos River and the Rio Conchos, is the only major river in the region. This river system is home to native minnow, sucker, catfish, killifish and sunfish species, two species of gar (*Lepisosteus oculatus*, *L. osseus*), and a rare sturgeon (*Scaphirhynchus platorhynchus*).

The Chihuahuan Desert herpetofauna is extremely diverse with the species assemblages of Big Bend being considered remarkable (Dinerstein et al. 2000). The intact desert scrub, woodland and grassland habitats found there are occupied by a wide array of species including 34 species of snakes, 21 species of lizards, and five species of turtle. In the Chihuahuan Desert Network parks several lizards are endemic, including the Texas banded gecko (*Coleonyx brevis*), reticulated gecko (*C. reticulatus*), greater earless lizard (*Cophosaurus texanus*), several species of spiny lizards (*Sceloporus spp*.), and marbled whiptails (*Cnemidophorus tigris marmoratus*). Representative snakes include the Trans-Pecos ratsnake (*Elaphe subocularis*), Mexican garter snake (*Thamnophis eques*), and whipsnakes (*Masticophis taeniatus* and *M. flagellum lineatus*) (Brown 1994).

E. Biophysical Overview of the Chihuahuan Desert Network Parks: Summary of Resources and Management Concerns

Approximately 4,460 sq. kilometers (1,722 sq. miles) of the total land area of the Chihuahuan Desert is contained in the national park units comprising the Chihuahuan Desert Network. While this only comprises approximately 0.07% of the total land area of the Chihuahuan Desert (including both the U.S. and Mexico), it represents the nation's most significant areas of preserved Chihuahuan Desert landscape.

These park units are an important component of the entire ecoregion and are integral keystone ecosystems to protecting and preserving the biodiversity of the entire Chihuahuan Desert Ecoregion. Therefore, it is imperative that the six parks, along with Chamizal National Monument a fellow Chihuahuan Desert park, network and partner with other protected areas, agencies, institutions, organizations, governments both in the U.S. and Mexico, and others to promote research, investigation, inventory and monitoring, and conservation of this vital ecoregion.

<u>The Chihuahuan Desert Network Parks</u>:

The Chihuahuan Desert Network Parks are located in the Northern Chihuahuan subregion of the Chihuahuan Desert Ecoregion (Dinerstien et al. 2000). This region is dominated by Chihuahuan Desert Shrub which constitutes approximately 50% of the total cover. The region was probably once as much as 50% grassland, but today, grasslands cover only about 25% of the region. Approximately 7% of the Northern Chihuahuan subregion consists of montane and woodland habitats, characterized by higher elevation communities with intact habitats, species assemblages and endemism (Dinerstein et al. 2000). Two of these conifer forests and evergreen Madrean woodlands are found in the sky-islands of network parks (Brown 1994).

Three of the Chihuahuan Desert Network parks, Big Bend NP, Fort Davis NHS and Guadalupe Mountains NP, are located in the Trans-Pecos region of western Texas, which is considered physiographically distinct from the rest of the state due to the presence of low, arid basins interspersed with numerous mountain ranges (Powell 1998). Elevations in the Trans-Pecos range from approximately 305 meters (1,000 feet) at the mouth of the Pecos River to approximately 2,667 meters (8,749 feet) at the top of Guadalupe Peak. The Trans-Pecos region is also notable for the "sky island" vegetative communities, which may be phytogeographically related to the communities in other mountain ranges of the southwestern United States and northern Mexico (Powell 1998).

Big Bend NP is located in the southern part of the Trans-Pecos along the boundary with Mexico. It is bounded by the Rio Grande on the south and together with the Rio Grande Scenic River includes over 200 miles of that river. Elevation ranges from 548 meters (1,800 feet) at the Rio Grande to 2,377 meters (7,800 feet) atop Emory Peak in the Chisos Mountains. The Chisos Mountains form a "sky island" typical of the Trans-Pecos. The climate is arid, and characterized by hot, dry summers and cool, dry winters. Average annual precipitation ranges from 25-46 centimeters (10-18 inches), increasing with changes in elevation. The majority of the precipitation occurs between June and October. Summer high temperatures regularly exceed 38° C (100° F) from June through August, while winter lows can reach the freezing mark. It is the largest protected area representative of the Chihuahuan Desert and is classified as a U.S. Biosphere Reserve.

Fort Davis NHS is located in the central part of the Trans-Pecos region. It is located at the eastern side of the Davis Mountains, the largest mountain range in the Trans-Pecos. These mountains were formed by volcanic eruptions during the Tertiary period and form one of the Trans-Pecos "sky islands". The climate is the typical arid climate of the northern Chihuahuan Desert, with annual rainfall averaging 48 centimeters (19 inches). The elevation and location of the park places it in a transitional zone between desert grasslands and shrublands and the higher elevational vegetative communities where desert-shrubland mixes with cacti and pinyon-juniper woodland.

Two of the Chihuahuan Desert parks, Carlsbad Caverns NP and Guadalupe Mountains NP, are located in the Guadalupe Mountains of Texas and New Mexico, along the edge of the Permian Basin, which was once a vast inland sea. The Guadalupe Mountains and the Guadalupe Escarpment are a Permian age, limestone geological formation, of which the Capitan Reef is a significant section.

Guadalupe Mountains NP is located on the Texas-New Mexico border, on the northern end of the Trans-Pecos region. It is located on the edge of the Permian Basin in the highest elevations of the Guadalupe Mountains. Geological sections of the Capitan Reef geological formation and its related components have been designated an International Benchmark Standard for geology. Elevations range from 1,204 meters (3,624 feet) on the alkali flats to 2,584 meters (8,749 feet) atop Guadalupe Peak, the highest point in Texas. The climate is arid, and characterized by hot, dry summers and cool, dry winters. Average annual precipitation ranges from 15-51 centimeters (6-20 inches), and increases from the west to east and with increase in elevation. The majority of the precipitation occurs between June and October. Soils are typically shallow and alkaline and are characterized by scattered deposits of salt, gypsum, sand, clay, or gravel. A madrean community and relict coniferous forest is found in the "sky island" located in the park's high country.

Carlsbad Caverns NP is located in southeastern New Mexico near the northeast end of the Guadalupe Escarpment, in the northern reaches of the Chihuahuan Desert Ecoregion. It is located immediately north of the Trans-Pecos region of Texas and is very closely associated physiographically to that region. Carlsbad Caverns is noted for its limestone caves, over 90 in number, which represent some of the world's best known caves, including Carlsbad Caverns and Lechugilla Cave. It is designated a World Heritage Site, for the protection of "physical and biological formations and groups which are of universal world-wide value and interest." These caves support large colonies of cave-dwelling bats, including a significant maternity roost of the Mexican Free-tailed Bat (*Tadarida brasiliensis mexicana*) in Carlsbad Caverns. The climate is arid, with precipitation ranging from 15-25 centimeters (6-10 inches), with intense thunderstorms occurring during the summer. Elevation ranges from 1,096 meters (3,595 feet) to 1,987 meters (6,520 feet) on the top of the Capitan Reef. Soils are shallow and tend to be alkaline, and are characterized by scattered deposits of salt, gypsum, sand, clay, or gravel.

White Sands NM is located in the Tularosa Basin of south-central New Mexico, and is somewhat geographically separated from the other five parks. The Tularosa Basin represents the easternmost extent of the Basin and Range geologic province, and was formed by down-dropping action that occurred along the fault lines between the San Andres and Sacramento Mountain ranges. The basin extends 241 kilometers (150 miles) from north to south, and up to 96 kilometers (60 miles) from east to west. The highest peak in the Sacramento Mountains stands more than 2,436 meters (7,988 feet) above the lowest point of the basin, Lake Lucero (1,186 meters; 3,891 feet) (Houk and Collier 1994). The climate is arid, with precipitation delivered primarily in the form of intense summer storms. Average annual rainfall ranges from 15-25 centimeters (6-10 inches) and increases across the basin from west to east. Soil is saline and nutrient-poor, characterized by high concentrations of sodium chloride brines, calcium bicarbonates, calcium magnesium bicarbonates, and calcium sulfates that form the white gypsum dune fields (Houk and Collier 1994).

Amistad NRA is located in the eastern extreme of the Chihuahuan Desert in Texas. Amistad lies in the basin of the Rio Grande just east of the Devil's River. Amistad NRA straddles a zone of transition between the Chihuahuan Desert Ecoregion of the Trans-Pecos, the Edwards Plateau Savannah Ecoregion of the Edwards Plateau, and the Tamaulipan Mezquital Ecoregion of the South Texas Plains (Ricketts et al.. 1999). The Edwards Plateau is characterized by low to middle elevation limestone bedrock plains, undulating drainages, and steep-sloped canyons, with elevations ranging from 30 meters (100 feet) to more than 914 meters (3,000 feet). Soils are variable in type, but tend to be shallow. Average annual precipitation increases from west to east, ranging from 38-84 centimeters (15-33 inches) with peaks in May/June and September (Hatch et al.. 1990). The limestone caves of the Edwards Plateau support some of the largest assemblages of cave-dwelling bats in the world, including maternity roosts of the Mexican Free-tailed Bat (*Tadarida brasiliensis*), and a number of endemic invertebrates, and aquatic vertebrates. Ricketts et al. (1999) rank it among the top ten ecoregions for reptiles and birds, and assign it a Class 2 Conservation Status (defined as a regionally outstanding ecoregion requiring immediate protection). The Amistad Reservoir is located near the Balconian Escarpment, which forms the southern and eastern boundary of the Edwards Plateau, and which is listed as a priority conservation site by Ricketts et al.. (1999). Canyons associated with this escarpment contain numerous springs, and support short to mid-grass and oak/mesquite associations.

Resource Issues and Concerns:

Much of the land administered by the Chihuahuan Desert Network parks has a history of resource use that has resulted in significant alteration. Descriptions from the 1800s described the Chihuahuan Desert landscape as dominated by native grasses, with widely scattered shrub cover, and extensive cienegas and riparian gallery forests. However, a history of fire suppression, over-grazing, and competition from non-native species has resulted in loss of the native grasses and the invasion of the grasslands by woody shrubs and small trees. Diversion of water from the riparian areas has impacted river flows, altered flood patterns, and destroyed most of the gallery forests and cienegas. Mexican Wolves (*Canis lupus baileyi*) have been extirpated from the region, while Antelope (*Antilocapra americana*) and Black-tailed Prairie Dog (*Cynomys ludovicianus*) numbers are much reduced from their former abundance. Today, threats to the

Chihuahuan Desert include accelerating development around urban centers and along the US-Mexico border, agricultural expansion, overuse of riparian areas, air and water pollution, invasive non-native species, and illegal collection of native species (Ricketts et al.. 1999).

As part of the process of prioritizing projects for the Biological Inventory, each park was asked to present their most pressing resource and management issues. More detailed overviews of the history, geophysical and biological resources, and the management concerns of the Chihuahuan Desert Network parks are provided in (Appendix A). Several management issues emerged as being of concern to multiple parks in the network:

Loss or Degradation of Ecosystems or Vegetative Communities:

Among the concerns most frequently cited by the Chihuahuan Desert Network parks were loss and degradation of riparian ecosystems. Specific communities named for investigation included the isolated springs and seeps at Big Bend NP and Guadalupe Mountains NP, the historic cottonwood gallery at Fort Davis NHS, the ephemeral wetlands at White Sands NM, and Rattlesnake Springs at Carlsbad Caverns NP. Water diversion and invasion by non-native species are either suspected, or confirmed, to be disrupting native floral and faunal assemblages at most of these sites. The Rio Grande and its tributaries suffer from pollution and the natural flow has been diverted upstream from Big Bend NP and Amistad NRA for urban, industrial and agricultural purposes. Counteracting the further degradation of the Rio Grande and its riparian corridor is a top priority for Big Bend NP, while Amistad NRA requires investigation into the effects of fluctuating reservoir levels on riparian communities at the disturbed edges of the reservoir. The McKittrick Creek watershed is of concern to Guadalupe Mountains NP.

Several parks noted the need to preserve and manage isolated patches of critical or unique vegetative communities and associated fauna. Carlsbad Caverns NP lists Walnut Canyon as of particular concern due to high levels of visitor use and the presence of rare taxa. Relict populations of plants and animals persist in isolated montane habitats at Carlsbad Caverns NP, Guadalupe Mountains NP, and Big Bend NP, but are at risk from climate shifts, invasive non-native species, fire, and possible management actions. Grassland areas of Big Bend NP, Carlsbad Caverns NP, White Sands NM and Amistad NRA have been degraded due to pre-park agricultural impacts and fire suppression, as well as occasional current trespass grazing by livestock. Guadalupe Mountains NP also cites the need for better understanding of past grazing effects on recently acquired parkland.

Boundary Effects:

In addition to agriculture and grazing, urban development along the boundaries of Amistad NRA may result in fragmentation of the existing vegetative communities and increase the potential for invasion by non-native plants. Oil and gas development on land adjacent to Carlsbad Caverns NP poses risks of vegetation fragmentation and disturbance, and air and water degradation. Generalized concerns over air and water pollution are common to all the parks.

Visitor Impacts:

Among the visitor impacts listed were the effects of recreational fishing and stocking of game fish on the native fish and amphibian populations of Amistad Reservoir, and backcountry use in Carlsbad Caverns NP, Amistad NRA, Big Bend NP and Guadalupe Mountains NP. Automobile effects, vandalism, and trail degradation were noted as particular problems at Carlsbad Caverns NP. River use and associated impacts are of concern to Big Bend NP. Illegal collection of native species, particularly reptiles and cacti, is suspected to be a problem at many network parks.

Taxa and Species Specific Resource Issues:

Taxa-specific and species-specific topics of concern (which might be more directly addressed by the Biological Inventory) were also noted. Parks are concerned about sensitive, threatened and endangered species, about non-native species, and about the general lack of baseline data.

Management of Sensitive, Threatened, and Endangered Species:

The inventory and management of species listed as Sensitive, Threatened, or Endangered by state or federal agencies was of concern to all parks. Lists of the species of special concern for each park are provided in Appendix A. In addition, a network-wide chart reflecting the overall picture of the Species of Special Concern for the Chihuahuan Desert Network is included in Appendix G.

Non-Native Species:

Invasive plant and animal species have significantly disrupted natural ecosystem function in many parks, yet many parks are lacking specific inventory distribution and abundance data on these species, which hinders efforts to control them. Among the recognized threats is the invasion of tamarisk into riparian areas at Amistad NRA, Big Bend NP, and White Sands NM. Other non-native plants, including numerous grasses, are problematic at Big Bend NP, Carlsbad Caverns NP, and Guadalupe Mountains NP. Carlsbad Caverns NP reports particular concern over the invasion of Rattlesnake Springs by Russian Olive (*Elaeagnus angustifolia*) and Johnsongrass (*Sorghum halepense*). Non-native ungulates include Gemsbok (*Oryx gazella*) at White Sands NM, Feral Hogs (*Sus scrofa*) at Amistad NRA and Big Bend NP, and feral goats and Barbary Sheep (*Ammotragus lervia*) at Carlsbad Caverns NP and Guadalupe Mountains NP. Barbary Sheep are also present at Big Bend NP. Nutria (*Myocaster coypus*) threaten Amistad NRA and Big Bend NP riparian communities, and Big Bend NP also reports that 13 non-native fish species have been identified in the Rio Grande.

Lack of Baseline Data:

In many cases, the concerns outlined above reflect the need for finer-scale inventory and monitoring programs directed at specific species, taxa, or communities. Restoration and protection of critical ecosystems and native species; mitigation of visitor and boundary effects; and the effective management of Threatened and Endangered and non-native species, depends on the ability to identify key mechanisms and species involved, and to document and monitor long-term changes in species distribution, abundance, and habitat use. The initial stages of the Inventory and Monitoring Program can be used to help provide baseline data against which future changes may be measured.

All of the network parks identified the lack of basic biological information as a major obstacle to establishing sound resource objectives and management policies. For example, Fort Davis NHS lacks basic inventory information for any of the vertebrate taxa. Natural resources at Fort Davis NHS have typically been managed with an eye toward maintaining historic landscape aesthetics. Accurate baseline information on vertebrates present at the site would allow them to be better incorporated into the management scheme. White Sands NM needs baseline inventories of plants, reptiles, small and medium-sized mammals, and birds, but is particularly concerned with lack of information on the status and distribution of amphibians associated with ephemeral wetlands. Complete and current inventory information is lacking for herps at Amistad NRA, Big Bend NP, Carlsbad Caverns NP, and Guadalupe Mountains NP. Amistad NRA ranks baseline inventories of plants and fish as among its highest priorities. Big Bend NP needs to understand more fully the current status of at-risk species of the Rio Grande and its associated riparian community, as well as a more complete picture of the species assemblages associated with other critical ecosystems in the park.

II. PROJECT DESCRIPTION

A. Chihuahuan Desert Network Organization & Activities to Date

The Chihuahuan Desert Network Inventory & Monitoring pre-proposal was completed in December, 1999, and submitted to the Washington office for approval. In February, 2000, an initial scoping meeting was held in Carlsbad, New Mexico, and work began. The network decided to accomplish the initial phases of the I&M program, including data mining and inventory study plan development, under an interagency cooperative agreement with the USGS-BRD. A work order was awarded to the Texas Cooperative Fish and Wildlife Research Unit of the U.S. Geological Survey—Biological Resources Division (USGS-BRD) at Texas Tech University in Lubbock, Texas. This work order was established in June and work commenced. Initial planning was accomplished and graduate students were hired at Texas Tech to begin data mining in the six parks. A full report of that data mining effort is included in Appendix C.

A full scoping meeting with 50 individuals in attendance was held in Odessa, Texas, on May 30-31 and June 1, 2001. Input from that meeting was captured in minutes for that meeting, available upon request. This input was then used in completion of this final study plan for inventory work. This study plan completes the work order with the Texas Cooperative Fish and Wildlife Research Unit at Texas Tech. The network is currently in the process of hiring a full-time (term) I&M Coordinator to help coordinate and lead future I&M program activities.

The network has identified several organizational groups to promote intra-park coordination and cooperation towards network goals. A working group of all of the network resource management staff from all six parks has met several times. A mailing list has been established on email to keep all network Resource Management personnel advised on I&M activities. A Steering Committee was established of members from the broader working group to coordinate the biological inventory planning effort. Lastly, the Superintendents are organizing into a Chihuahuan Desert Network Board of Directors to help provide leadership to the network's efforts. It is envisioned that this Board of Directors will be able to function both in the I&M arena and in a broader sense, to support and promote efforts in the Chihuahuan Desert Ecosystem at many levels.

B. Existing Information on Vascular Plants and Vertebrates

<u>Expected Species Lists:</u>

The NPS Inventory and Monitoring Program Guidelines established that the first objective of the inventory program is to provide documentation of 90% of the vertebrate and vascular plant species that occur in each park. The Chihuahuan Desert Network, therefore, attempted to first assess the current inventory status in the six parks, in order to better prioritize future inventory research efforts.

The original "expected species" lists were generated using a variety of source material, including park checklists, data from the Texas GAP Analysis program, the Natural Science Research Laboratory of the Museum of Texas Tech University, and the Condor database (Schmidly).

However, after review by park specialists and experts in each taxon, it was decided that the geographical coarseness of some source material resulted in too broad a definition of "expected species". For example, some plant species lists were originally based on the ten (10) vegetation areas described by Gould et al.. (1960), but due to the size and geographical diversity of each of the vegetation areas, the lists included species that did not occur within the boundaries of the parks in question. Questions also arose as to whether to include extirpated, non-native, migratory, etc., species in the 100% yardstick of expected species.

A conservative, but somewhat flexible, standard for the "expected species" lists was eventually adopted. Most of the parks felt confident that their park checklists were complete enough to use as the 100% yardstick, when supplemented by expert opinion. In those cases where checklists were absent, incomplete, or outdated, the Chihuahuan Desert Network relied on expert opinion. The lists included only those species that might reasonably be expected to *currently* occur within park boundaries as residents or regular visitors; extirpated species were excluded. In all cases, the reported percentages of documented species should be considered estimates only, as it is anticipated that the precise number of species comprising each "expected species" yardstick will be adjusted as research continues in the parks. This is particularly true of the plant lists, since current 100% yardsticks are known or strongly suspected to be incomplete for several parks.

Additional challenges were faced in deciding what constituted adequate "documentation" of a species. Although voucher specimens are considered by the scientific community to be the most desirable form of documentation, such a specimen establishes the occupancy of only a single individual at a single point in time and space. For purposes of estimating a percentage value, the Chihuahuan Desert Network considered a species "documented" when a single voucher specimen had been located, regardless of when it was collected. Realistically, however, it seems unreliable to rely on a single voucher specimen or upon multiple specimens collected more than a decade ago, to verify the current presence of a species in a park.

Other forms of documentation such as photographs, physical evidence (e.g., scat, tracks, etc.), and observation or research records were also used to verify the presence of a species. The authority assigned to such evidence might arguably be less than that of a voucher, but it remains the primary source of documentation for some taxa. Documentation was typically accepted only when it was derived from inside park boundaries, but in some cases it was deemed suitable to include records derived from locations within 1-mile area of park boundaries. Such records were included in areas that were comprised of contiguous vegetative structure, and where the park boundary formed no apparent geophysical or biological barrier to movement of the species in question.

<u>Data Mining and Inventory Completeness:</u>

The first step in the data mining process was to have the resource staff at each park complete a self-assessment of the inventory completeness by taxa for their park. These self-assessments are included in Appendix C for each park. While these assessments are subjective, they provided a starting point both to begin data mining and to measure or assess data mining. They also provided an overview of the perceived inventory completeness in each park to evaluate data mining against.

Data mining was initiated at each park to begin to capture the vast amount of information that has accumulated. Existing information documenting vertebrates and vascular plants in the Chihuahuan Desert Network was scattered throughout various offices, files, and databases in each of the network parks. The availability of information reflected differing budgets, facilities, and research activities at each park. Museum collections housed at the parks were found to be in varying stages of maintenance; some collections lacked adequate storage facilities, and others were only partially catalogued on the ANCS+ database.

Documentation of target species was obtained by examining the museum collections housed at the parks, and by looking at records of Collecting Permits and Annual Investigator's Reports. Most parks also used Wildlife Observation Cards to document animal sightings by park visitors and staff, but such data was sometimes of dubious quality and, therefore, less desirable than the other forms of documentation. Observation data was used only when park personnel considered the observer to be reliable.

Museum facilities throughout the U.S. (Table 2) were solicited for records of voucher specimens collected in the counties that encompassed park property. Of the 32 museum facilities from which information was originally requested, only nine were able to respond with data, or were available on-line. Websites indicate that several additional collections will soon be available for on-line searches.

Several museums informed us that they lacked the ability to electronically access the information we requested, but suggested that on-site visits would uncover usable specimens. Other museums failed to respond at all and we speculate that, in some cases, concern over issues of specimen ownership may have contributed to their reticence.

Table 2. Museum facilities contacted or searched for purposes of determining voucher specimen status for the Chihuahuan Desert Network.

1. Academy of Natural Sciences (Philadelphia, PA)
2. American Museum of Natural History (New York, NY)
3. Angelo State University (San Angelo, TX)
4. Baylor University (Waco, TX)
5. Big Bend Natural History Association (Big Bend National Park, TX)
6. Corpus Christi State University, Vertebrate Collection (Corpus Christi, TX)
7. Carnegie Museum of Natural History (Pittsburgh, PA)
8. Dallas Museum of Natural History (Dallas, TX) *
9. Field Museum of Natural History (Chicago, IL) *
10. Fort Worth Museum of Science and History (Fort Worth, TX)
11. Louisiana State University Museum of Zoology (Baton Rouge, LA)
12. Museum of Southwestern Biology, University of New Mexico (Albuquerque, NM) *
13. Michigan State University (Lansing, MI)
14. Museum of Texas Tech University Mammal Collection (Lubbock, TX) *
15. Museum of Vertebrate Zoology, University of California (Berkeley, CA)
16. Midwestern State University, Collection of Recent Mammals (Wichita Falls, TX)
17. Natural History Museum of Los Angeles County (Los Angeles, CA) *
18. Smithsonian National Museum of Natural History (Washington D.C.)
19. Southwest Texas State (San Marcos, TX)
20. Stephen F. Austin State University, Department of Biology (Nacogdoches, TX)
21. Sul Ross State University Vertebrate Collection (Alpine, TX) *
22. Texas A&M University (Kingsville, TX)
23. Texas A&M University, Texas Cooperative Wildlife Collection (College Station, TX) *
24. Texas Natural History Collections, Texas Memorial Museum (Austin, TX)
25. Texas Wesleyan University, Museum of Zoology (Fort Worth, TX)
26. University of Illinois Museum of Natural History (Urbana-Champaign, IL)
27. University of Kansas Natural History Museum (Lawrence, KS)
28. University of Michigan Museum of Zoology (Ann Arbor, MI) *
29. University of Texas Vertebrate Collection (Arlington, TX)
30. University of Texas Natural History Collection (Austin, TX) *
31. University of Texas, Mammal Division, Laboratory of Environmental Biology (El Paso, TX)
32. Witte Memorial Museum (San Antonio, TX)

* Facilities who responded and from whom voucher information was retrieved.

Data mining, to date, has been assembled to reflect the current knowledge of the status of inventory completeness. Table 3 presents a simplified breakdown of the estimated percentages of expected species that are currently documented for each park. The percentages were calculated by comparing the number of species documented, as described above, to the number of species on the "expected species" lists. The percentage figures incorporate all evidence judged to be of reliable quality, including voucher specimens, photographs, physical evidence, and observation records. A good portion of the available observation data has not yet been examined, and its potential use will be assessed as the inventory project proceeds.

A more detailed discussion of the data mining to date and a listing of the resources used to document taxa at each park is available in Appendix C.

Table 3. Estimated percentage of expected species in each taxonomic group currently documented for the Chihuahuan Desert Network.

	Amphibian	Bird	Fish	Mammal	Plant*	Reptile
AMIS	75	81	96	57	~ 40	46
BIBE	83	73	72	70	~ 60	88
CAVE	64	96	100	95	~ 65	79
FODA	57	51	-	23	~ 60	68
GUMO	56	74	80	86	~ 55	52
WHSA	0	68	33	61	~ 15	28

* Percentage calculations using voucher documentation only, and based on "expected species" lists that are suspected to be incomplete in some cases.

Several parks have expressed concern over the taxonomic accuracy of their collections, and similar concerns were expressed at the Scoping Meeting (held in Odessa, TX on 30 May through 1 June 2001) regarding the accuracy of taxonomic identification at other museum facilities. No attempt was made during the initial data mining phases of this project to verify collections for accuracy. Taxonomic review and verification of park collections will be incorporated into the network's inventory program.

It has been a challenge to assemble a complete picture of past inventory work, and the current knowledge rarely results in the desired 90 % level of documentation. Although the figures shown in Table 3 incorporate the majority of readily accessible information, additional information sources are known to exist. These percentage figures are only current known status based on initial data mining. Further retrieval and compilation of data will continue throughout the duration of the Inventory and Monitoring Program and are expected to continuously adjust these figures. As further documentation is recovered, it will be entered into the NPSpecies database so that multiple sources may eventually be cited as verification of the presence of any given species. The use of multiple data sources for species verification will result in more robust documentation of species than does the simplified approach used to generate these preliminary percentage figures.

<u>Data Management:</u>

Several NPS databases are being used to organize information pertaining to the Inventory & Monitoring Program. These include NPSpecies, the National Parks Bibliography (NPBib) (a database that the previous Natural Resource Bibliography (NRBib) has been combined with), and the Dataset Catalog.

NPSpecies **–** To this point, most of the data mining efforts by the network have centered on assembling species lists and occurrence data for NPSpecies. During the months of February – May, 2001, existing species documentation information was compiled for the Chihuahuan Desert Network, under the agreement with the Texas Cooperative Fish & Wildlife Research Unit. Much of these data were only available in paper form and the information was entered into electronic Excel spreadsheet format. These electronic species list files still need to be uploaded into NPSpecies. The addition of data to NPSpecies is expected to be ongoing in the early years of the inventory project, as further voucher sources and informational leads are investigated. Data that is entered into NPSpecies will be subject to ongoing authoritative review for accuracy and completeness. The database will also allow species lists to be generated according to filtering criteria such as Threatened and Endangered status, residency status, origin, etc. This function will enable park staff to generate "expected species" or "100% yardstick" lists according to the criteria they deem useful or applicable to any particular situation.

NPBib/NRBib **-** An extensive NRBib database population effort was completed by the National Park Service in the Chihuahuan Desert Network parks in the mid 1990s. Bibliographic entries included typical references such as reports, publications, references for manual and electronic data files, photos, and raw data sheets. A search of a year-old ProCite version of NRBib yielded 1,664 references for vertebrates and vascular plants in the Chihuahuan Desert Network (Table 4). At most parks, time limitations prevented a thorough examination of library materials during data mining to update this database. The quality and consistency of data entry into the NPBib since the original database was populated appears to have been variable from park to park. While some parks have been able to keep their bibliographical database current, others have not, resulting in a number of documents present at most parks that have not been entered into NPBib. Now that NPBib has replaced NRBib and is available on the web, update of park bibliographical references into NPBib to bring the parks current still needs to be done. The Chihuahuan Desert Network anticipates that updating and maintenance of NPBib will be a substantial task that will require on-going effort throughout the Inventory and Monitoring Program.

Table 4. Number of publications identified for the CDN, based on a search of the NRBib ProCite database. (A listing of all references has been produced by taxon by park, but is not included in this proposal).

	Mammal	Bird	Reptile	Amphibian	Fish	Plant	Total
AMIS	16	16	4	4	13	12	**65**
BIBE	132	98	37	25	53	129	**474**
CAVE	73	73	42	41	51	106	**386**
FODA	1	0	0	0	4	16	**21**
GUMO	89	95	44	40	101	159	**528**
WHSA	28	23	15	12	17	95	**190**
Total	**339**	**305**	**192**	**122**	**239**	**517**	**1664**

***Dataset Catalog* –** This database stores metadata on a variety of datasets, and will be used to compile metadata on inventory and monitoring datasets for the network. Currently, little data has yet been stored in this database. This is a need that remains to be addressed.

Maps and GIS Themes - Spatial Data is an extremely important component of the network's inventory and monitoring program. Spatial data is increasingly used for analysis of data in decision making. These data sets will be useful in selecting inventory and monitoring random sampling locations (e.g., stratification). In addition, GIS data will be used to organize data on species occurrences, sampling points, survey routes and much more. In-house GIS capability varies widely among the CDN parks. However, there is a universal need for additional GIS data in all six parks. An initial assessment of GIS layers currently available to the network parks is shown in Appendix H. This data is available in the parks and some of it is also posted on NPS GIS web pages.

C. Inventory Priorities:

<u>Scoping Meeting Overview:</u>

An Inventory Scoping Meeting for the Chihuahuan Desert Network was held in Odessa, Texas on May 30, 31, and June 1, 2001. The purpose of this meeting was to solicit input from a broad range of experts and knowledgeable individuals about the status of the inventories of biological resources in the six park units. A total of 50 individuals participated in this meeting and provided insight into the existing knowledge base. A list of participants is attached in Appendix J. The meeting began with an overview of the goals of the I&M Program and a discussion of the requirements of the inventory stage; specifically, the need to document 90% of the vertebrate and vascular plant species that are expected to occur in the CDN parks. This overview was followed by a series of individual sessions devoted to the discussion of the current status of inventory information for each taxon, and the best approach for attaining the desired 90% level of documentation.

Each session began with a review of the current estimated inventory status of the target taxon and the voucher specimen sources that had been investigated to that point in time. Participants were encouraged to review the "expected species" lists, identify additional voucher sources, and suggest priorities for further inventory work. Finally, smaller groups of interested experts participated in "breakout" sessions in order to establish specific logistical and budgetary requirements needed to accomplish the recommended inventory goals.

This scoping meeting provided the Chihuahuan Desert Network parks with information regarding data mining sources, relevant information on park resources, their status, the status of inventories and research needs in the parks. Participants also provided the network with recommendations for future inventory work and priorities for this work. Minutes of this meeting were compiled for future reference and are available upon request.

At the conclusion of the meeting, Chihuahuan Desert Network park management and resource managers (Appendices K & L) held a round-table discussion to further discuss inventory needs, refine priorities among the recommended projects, and determine the general allocation of available funds for Fiscal Years 2002-2004. The scoping meeting was extremely useful in helping the network parks to chart the course for the future.

<u>Establishment of Inventory Priorities:</u>

Several factors were used as guidelines in helping to assess the inventory needs, and to establish inventory priorities and allocation of funding for proposed inventory projects:

1) *Current estimated inventory status of each taxon* – Inventory needs for each taxon were projected on the basis of the current estimated level of documentation, as shown in the previous section. An adjective rating was given each taxon based on a percentage scale to reflect the relative completeness and thus the related level of need for each taxon in each park (Table 5). A percentage level of 75% was chosen as the level below which a taxon would be deemed a “high” priority need. Based on the existing data mining, amphibians, reptiles, birds, and mammals were all shown to be of high priority in four of the six Chihuahuan Desert Network parks. Fish was of high priority at White Sands NM and Big Bend NP. Using this factor, plant inventories attained high priority in all six parks. This resulted in 24 of the possible 36 priority levels as in high need of inventory work.

Table 5. Adjective Priority level for further inventory work in the Chihuahuan Desert Network (based on current estimated documentation of species.)

	Amphibian	Bird	Fish	Mammal	Plant	Reptile
AMIS	Medium	Medium	X	High	High	High
BIBE	Medium	High	High	High	High	Low
CAVE	High	X	X	X	High	Medium
FODA	High	High	-	High	High	High
GUMO	High	High	Medium	Low	High	High
WHSA	High	High	High	High	High	High

Note: “-“ indicates that the taxon does not occur. “X” indicates inventory $\geq$ 90 % complete. “Low” priority indicates inventory is 85-89 % complete, “Medium” priority indicates inventory is 75-84 % complete. “High” priority indicates inventory is $\leq$ 74 % complete.

***2) Current inventory status in each park* –** The levels of documentation shown in Table 5, reflect resource managers concerns regarding the inadequacy of baseline data in all of the parks.

It should be noted here that this is a relative rating and the adjective priority level assigned was subjective. This analysis served as a tool to assist managers in validating or refuting the current beliefs on the status of the various inventories. Due to the current inadequate level of databases and insufficient data mining, these percentages reflect only a current state of knowledge and therefore may not be totally reliable and were used accordingly as a relative tool in planning. In addition, percentages and their relative importance across taxa can be mis-leading, especially when small numbers of species are concerned. For example, if a park has 3 of the 6 expected species of fish, they would have 50% documentation of fish. A relatively small effort could easily raise that percentage. On the other hand, when the expected species list of vegetation is several hundred species, it would take a correspondingly greater number of species to affect the percentage results.

Looking at these results from another perspective, if one looked at the percentages of vouchered species under 50% as the cut-off to determine a high priority, the results would be as follows. High priority would be given to fish at White Sands, mammals at Fort Davis, amphibians and reptiles at White Sands, reptiles at Amistad, and plants at Amistad and White Sands.

3) Resource and management concerns of each park - Details of the resource and management concerns of the individual parks of the Chihuahuan Desert Network are outlined in Appendix A. As previously described, several issues emerged as being of concern to multiple parks (Table 6); these concerns ranged from species-specific to ecosystem-wide in complexity, and from localized to park-wide in scale. Although some of these resource concerns are well understood and subject to clearly delineated management policies, others are poorly understood. For example, when attempting to understand the effects of recreational fishing and stocking on the Amistad Reservoir vertebrate community, park managers lacked much of the basic information necessary to establish an effective management strategy.

Management concerns that are focused on such specific areas as riparian and grassland communities are frequently associated with additional issues of concern, such as impacts by non-natives, and with management issues associated with Threatened and Endangered species. When comparing the relative values of the proposed inventory projects, Steering Committee members examined the potential of the proposed inventory work to increase the baseline data available to the park managers, and to improve their ability to formulate effective management policies.

Table 6. Primary resource or management concerns cited by the Chihuahuan Desert Network parks.

RESOURCE or MANAGEMENT ISSUE – Parks Affected
Riparian Ecosystem Degradation - All Parks
T&E Species/Species of Concern - All Parks (see Appendix G)
Ecology & Control of Non-Native Species: • Tamarisk spp. - AMIS, BIBE, WHSA • Grass spp. - BIBE, CAVE, GUMO • Barbary Sheep - BIBE, CAVE, GUMO, AMIS • Feral Hogs - AMIS, BIBE • Nutria - AMIS, BIBE • Fish - AMIS, BIBE • Russian Olive – CAVE • Feral Goats – CAVE • Oryx – WHSA
Preservation of Critical or Isolated Ecosystems: • Desert Grassland - AMIS, BIBE, CAVE, GUMO • Mountain - BIBE, GUMO • Walnut Canyon – CAVE • Desert Scrub/Dunes – GUMO
Detrimental Visitor Impacts: • Illegal Collection of Plants and Animals - All Parks • Backcountry Use - AMIS, CAVE, GUMO • Auto Exhaust – CAVE • Vandalism – CAVE • Recreational Fishing/Stocking – AMIS
Detrimental Boundary Effects: • Oil/Gas Drilling – CAVE • Housing Development – AMIS • Adjacent Land Uses – All Parks

4) Expert Recommendations from the Scoping Meeting – The input and recommendations of the experts who attended the inventory scoping meeting carried considerable weight with the Steering Committee in evaluating priorities. Their recommended priorities, as identified in the Scoping Meeting Minutes, were used extensively in priority setting. The list of potential priority projects was partially derived from that input.

In addition, the input of the plant authorities weighed heavily into decisions regarding the establishment of inventory for plants in the network parks. They identified several concerns regarding the completeness and validity of the expected species lists, as well as serious questions regarding the accuracy of taxonomic identification of plant vouchers. Their collective recommendations were that while targeted and focused surveys could be done, especially in some remote or hot spot locations, they felt that continued data mining with accurate taxonomic work to accompany it would result in achieving the desired 90% documentation.

Collectively, all of the experts for all of the taxa groups identified continued data mining as an important task for the network to continue. There was almost universal agreement that the current level of documented vouchers and information is lower than actual levels of information available and reflects the need to continue data mining.

5) ***Budgetary constraints*** - A budget of $556,502 remains available to the Chihuahuan Desert Network for the next three fiscal years. The Network plans to hire a project Coordinator using part of these funds. This person would be responsible for coordinating data collection efforts and field inventories for the Network, and ensuring that data is properly entered into the appropriate electronic databases. Other responsibilities of this position would include negotiating cooperative agreements, working with investigators, and dealing with compliance issues and environmental assessments. Because further data mining was identified as a priority, it has been determined that the Network Coordinator will also be responsible for some or all of this work as well.

It was projected that a network coordinator would require an estimated $206 K for the remaining 3 years of the inventory effort. This left a balance of $ 350,502 remaining as available for inventory projects in the six parks. Inventory needs of over $1000K (Table 7) were identified during the scoping meeting. These do not comprise the entire scope of the projected needs, but only an initial assessment of the needs. The budget required to fund all of the identified inventory needs of the Chihuahuan Desert Network parks far exceeds the funds available.

Table 7. Summary of estimated budget requirements of all the Inventory Projects proposed during the Inventory Scoping Meeting.

PROJECT CATEGORY	PROJECTED BUDGET *
Amphibian/Reptile	$ 291.0 K
Plant	$ 115.0 K
Bird	$ 100.0 K
Mammal	$ 354.0 K
Fish	$ 52.5 K
Network Coordinator	$ 180.0 K
Total Required	**$ 1092.5 K**

* Includes ALL inventory projects determined to be of priority in the Chihuahuan Desert Network during the Inventory Scoping Meeting, Odessa, TX, June 1, 2001.

It is also interesting to note that of the total identified inventory projects, $128K of this work was identified as needed data mining.

Evaluation & Recommendations:

The managers and resource managers present at the scoping meeting concluded that an I&M Coordinator was the network's highest priority. It was established that this individual would also serve as a Data Manager for the network for the inventory phase of the program.

The park's representatives also concluded that data mining was a critical need. In addition, they concluded that funding should currently be directed toward those projects that are believed to offer the best chance of increasing species documentation for the parks and taxa in highest need.

Following a final round-table discussion, using the factors noted above, a potential list of inventory projects was chosen that were judged to be of high priority to the Chihuahuan Desert Network and reasonable in terms of cost (Table 8).

Table 8. Inventory projects proposed for funding (in order of priority). [1]

Program Area	Project	Cost [2]
CDN Coordinator	1. Network Coordination and Data Management	206
Amphibians	1. Data Mining (All Parks) 2. Baseline Inventory - Species Richness (AMIS, CAVE, GUMO, WHSA)	8 92
Birds	1. Data Mining (All Parks) 2. High-Elevation Breeding Bird Survey (CAVE, GUMO) 3. Riparian/Wetland Point-count Survey (AMIS, BIBE, CAVE, GUMO, WHSA) 4. Winter Grassland Bird Inventory (BIBE, GUMO)	15 2.5 25 2.5
Fish	1. Survey Rio Grande – Fish & Mussels (BIBE) 2. Survey Amistad Reservoir – Fish & Mussels (AMIS) 3. Data Mining (All Parks) [3]	30 20 -
Mammals	1. Data Mining (AMIS, BIBE, FODA, GUMO, WHSA) 2. 1st Year Baseline Inventory - Emphasis on Small Mammals & Bats (AMIS, BIBE, FODA, GUMO, WHSA)	45 55
Plants	1. Data Mining - Herbaria (All Parks) 2. Vegetation Inventory (AMIS)	30 25
Reptiles	1. Data Mining & Data Collection- incidental to Amphibian work [3]	-
	TOTAL	**556**

(1) Established at the Inventory Scoping Meeting in Odessa, TX, June 1, 2001.
(2) Approximate estimated costs ($ K) projected over FY02-FY04.
(3) Cost incorporated into budget for other inventory projects or for the Network Coordinator.

In some cases, the Steering Committee decided that further data mining efforts offered a more cost-efficient method of increasing species documentation than did field inventories. This was the case in regard to plants, where the subject matter experts all recommended that further data mining was necessary rather than field inventories to obtain the 90th percentile.

A proposed level of projected funding, by taxon (Table 9), was developed as a guideline for the Steering Committee to plan projects. Consideration was also given to having the continued data mining be done by the I&M Coordinator and by the PI's in the completion of individual projects. It was felt by many that the workload was such that the I&M Coordinator could continue the data mining efforts and obtain some assistance where necessary for taxonomic expertise.

Table 9. Final projected potential allocation of funds by taxa, available to the Chihuahuan Desert Network for FY02-04, as identified in the Inventory Scoping Meeting.

INVENTORY PROJECT CATEGORY	FUNDS ALLOCATED *
CDN Coordinator/Data Manager (GS-11, 3 years)	206 K
Amphibians	100 K
Birds	45 K
Fish	50 K
Mammals	100 K
Plants	55 K
Total Funds Allocated	**556 K**

* Determined by the Chihuahuan Desert Network Steering Committee; final round-table discussion, Inventory Scoping Meeting in Odessa, TX, June 1, 2001.

These lists were then modified by tailoring the scope of the proposed projects to the funds available, according to the Steering Committee's judgment of which projects would deliver the most usable information per dollar spent, and weighing in all of the factors discussed above. A final list of all projects recommended for funding and a list of all unfunded projects are included in Tables 10 and 11. Further details on the projected budget breakdown are available in Section V and in the final project statements and individual project budgets (Appendices D & E).

Table 10. List of Project statements for funded projects

	ID	$(1,000s)
Inventory Project Coordination and Data Management	ALLTAXA-01	206.
Development of standardized lists of plant and animal species of special concern And documentation of occurrences	ALLTAXA-02	
National and Regional Museum Searches and Data Mining	VERT-01	
Verification of park mammal, herpetofaunal and bird museum collection specimens in all six parks	VERT-02	
Avian inventory of riparian and wetland areas in CDN parks	BIRDS-01	25.0
Inventory of high elevation breeding birds in GUMO & CAVE	BIRDS-02	5.0
Inventory of winter resident grassland birds in BIBE & GUMO	BIRDS-03	10.0
Survey of fishes in the Rio Grande of the Big Bend National Park	FISHES-01	30.0
Survey of fishes of Amistad National Recreation Area	FISHES-02	20.0
General Amphibian & Reptile Inventory for CDN Parks	HERPS-01	177.0
Baseline inventories of small mammals and bats for AMIS and selected areas of BIBE and GUMO	MAMMALS-01	58.0
National and Regional Herbaria Searches and Data Mining (*partially funded*)	PLANTS-01	
General Floristic Survey of Amistad National Recreation Area	PLANTS-02	25.0
Verification of park herbarium specimens located in museum collection in all six parks	PLANTS-03	
	TOTAL	556.0 K

Table 11. List of Project Statements for unfunded projects	ID	$(1,000s)
Avian inventory of riparian and wetland areas in CDN parks (unfunded portion, years Two and three)	BIRDS-01	50.0
Baseline Inventories of small mammals and bats for selected CDN parks (AMIS, BIBE, FODA, GUMO and WHSA) (unfunded portion)	MAMMALS-01	238
Survey for aquatic exotics	VERT-03	250
Inventories for selected potential bird species of concern in the Chihuahuan Desert	BIRDS-04	74.5
Focused survey for the Rio Grande silvery minnow	FISHES-03	15.0
Survey of fishes at Rattlesnake Springs, Carlsbad Caverns NP	FISHES-04	2.5
Taxonomy and biochemical analysis of selected fish species in the Rio Grande at Big Bend NP and Amistad NRA	FISHES-05	315
Inventories for selected potential herp species of concern in the Chihuahuan Desert	HERPS-02	74.5
Exotic mammalian species of concern in CDN parks	MAMMALS-02	150
Inventories for selected potential mammalian species of concern in the Chihuahuan Desert	MAMMALS-03	74.5
Focused inventory of plants on WHSA	PLANTS-04	5.0
Focused inventory for vegetation of the lower canyons of BIBE	PLANTS-05	5.0
Focused survey for Guadalupe fescue at GUMO and BIBE	PLANTS-06	10.0
Focused inventory of plants in the remote western canyons of CAVE	PLANTS-07	10.0
Focused survey for peyote at BIBE	PLANTS-08	5.0
Focused inventory of plants in wetland areas on AMIS, BIBE, CAVE, GUMO, and FODA	PLANTS-09	20.0

Focused inventory of plants in the Brokeoff Mountains of GUMO	PLANTS-10	10.0
Multi-Park Inventory of Critical Non-Native Plant Species in the CDN	PLANTS-11	70.0
	TOTAL	1,379.0 K

D. Study Design and Survey Methods

The following section provides the overall study design, sampling framework and study methods for application to the overall inventory program for the Chihuahuan Desert Network. Ideally, these standards would be strictly applied to every project with unswerving detail. The realities of life are, however, that various factors may limit our ability to apply these universally. Our goal is to have the highest standard and highest level of inventory that funding, staffing and other limitations allow. As a result, we have shown an overall sampling framework and study methods that is our standard, even if we won't have projects, at this time, for which some of these standards would apply. They are included here in the hopes that if we were able to accomplish projects beyond our immediate abilities that the standards would be in place.

<u>Overview:</u>

The Chihuahuan Desert Network Steering Committee has concluded that the primary goal during the Inventory stage of the program is to attain the desired 90% level of documentation of vertebrate and vascular plant species. We have, therefore, opted to implement projects that are targeted toward the gaps in taxa documentation. We feel that the recommended projects are likely to yield the greatest amount of useful data, in areas of resource management concern, for the funds and effort invested. We anticipate that these projects will help establish the baseline data required to develop long-term monitoring strategies to be implemented during the second stage of the Inventory and Monitoring Program.

In this section we review some important considerations in the design of the inventory projects recommended for funding. It should be noted that, whether the inventory projects are implemented through agreements, cooperators, or in-house, the network will require that detailed research proposals be submitted prior to initiation of any work. Some of the specifics of study methodology are expected to vary according to the targeted taxon involved in each project.

<u>Design Considerations:</u>

The Chihuahuan Desert Network will use a combination of sampling approaches, depending on the status of inventory completeness for a given taxonomic group within a park and the size of the park. Our sample design incorporates probability-based sampling to allow park-wide extrapolation, while attempting to use inventory techniques that best capture true species richness. Unfortunately, it is often true that the best inventory techniques for capturing richness are insufficiently random, while purely randomized approaches frequently miss small-scale heterogeneity and localized 'hot spots.' The sampling design for each inventory project conducted in the Chihuahuan Desert Network will attempt to strike a balance between these two objectives.

Areas targeted for inventory within individual parks will be stratified based on physical and ecological attributes associated with the species and habitats of interest prior to selecting random sampling locations. Attributes for delineating strata may vary across taxonomic groups and may also be based on what spatial data is available for a given park. For example, plant inventories may be stratified on geologic substrate and bird inventories may be stratified on habitat (e.g., riparian areas). To the degree possible we will attempt to stratify on fixed landscape attributes (e.g., slope, elevation, aspect), however, in some cases it may be necessary to stratify on vegetation or other ecological attributes.

A stratified sampling framework is proposed for a few important reasons. First, strata provide a reference frame for extrapolation of inventory results and mapping species distributions. For targeted inventories a specific stratum may define the frame of reference for surveying (e.g., wintering grassland birds). For other inventories, it may be appropriate to intensify sampling within selected strata. A random set of coordinates will be drawn from all strata included in a project's reference frame. If select strata are to receive intensive sampling, additional coordinates will be selected and sampled. Increased sampling will be additive so that inventory data will not lose its value as classification systems change, or as succession alters vegetation boundaries.

It is anticipated that a grid-cell approach of identifying potential sampling locations (Fancy 2000) will be applied to an entire park. The starting point for this base grid will be randomly selected. Stratum of interest will be delineated over the base sampling framework for the park. Once strata have been delineated and mapped using existing GIS datasets, sampling will be completed for the taxonomic group of interest. Within each target stratum, all areas accessible for sampling will have an equal probability of being chosen. Where certain portions of a stratum are inaccessible to sampling, inferences will not be made to these areas. To the degree dictated by need, taxonomic group sampling points may be integrated. Design of inventories for some species of special concern may require departure from a random sampling approach. In these situations data will not be used in model-based estimates of species richness. An example of where such a departure may be warranted is an inventory for a rare plant that is restricted to highly localized outcrops, which would be missed in a random sampling design.

Standardized descriptions of vegetation types and physical site features will be used to classify all vertebrate sample points within the Chihuahuan Desert Network parks.
At this time it is not possible to know how many samples will be needed to achieve our inventory goals. Factors influencing the number of samples needed vary with taxonomic group, season, sampling effort, and variability in species occurrences and year-to-year variations. Assessing inventory completeness will be ongoing throughout the project. We will use these assessments to adjust our sampling intensity accordingly. In addition, significant portions of many parks within the network are inaccessible for sampling. Much of the canyon country is highly dissected and without roads and water. Only areas with reasonable accessibility will be included in the sampling pool.

Most parks in the network contain habitats that are either too small or too few to be captured by probability sampling. Park managers and biologists have identified these habitats as a high priority inventory because they are generally more sensitive to disturbance, they tend to support local hot spots of diversity, and they are often important in the life history of numerous species or habitat specialists. Randomized sampling designs are not a practical alternative for such areas. In small parks, rare features will be sampled exhaustively, while randomized selection will be employed for larger parks. In the case of linear features (e.g., cliffs), selection will be based on segments of the full feature length.

In some cases, data will be collected by non-random and opportunistic means, such as the inventory data that is anticipated to be collected on reptiles and large mammals. This approach may be required in special cases where systematic, random sampling will not adequately represent a particular taxon, or where funds limit inventory efforts. Emphasis will be placed on specific documentation of the type of efforts applied to obtain these data, with repeatability an important consideration. Nevertheless, the resulting data will be clearly reported as having been derived from haphazard sampling, and will be strictly excluded from analyses associated with the primary sampling scheme.

An appropriate sample size is difficult to predict and will vary depending upon the particular inventory objectives, the taxon involved, and the corresponding variation in occurrence and detectability through time and space. Furthermore, an appropriate sample size will also include consideration of budget and time constraints, as well as park size. We will use a range of approaches to determine an appropriate sample size. First, pre-inventory estimates of sample size will be based on expert opinion, review of similar studies, and taxon-specific standards. For example, estimates of variability for several taxa are available from several sources (e.g. Amphibian Count Database www.mp2-pwrc.usgs.gov/ampcv/ampdb.cfm; and the Power Analysis of Monitoring Program www.im.nbs.gov/powcase/powvariation.html). Using these estimates, a sample size can be calculated to estimate a population parameter within a specified level of precision (Elzinga, Salzar & Willoughby 1998). The scope of inventory work will include a range of sample sizes based on these estimates. For presence/absence inventories, species-area (effort) curves will be examined during the course of the survey. An appropriate sample is the size at which the cost of adding additional plots outweighs the potential benefit of capturing another species. The species-area relationship in Figure 3 shows a line with positive slope indicating the need for more intensive sampling. When estimating population parameters, variance-area (effort) curves will be examined. Similarly, an appropriate sample is the size at which the cost of adding additional plots outweighs the potential benefit of lowering the variance of the estimate (Figure 4).

Figure 3. Example of species-area relationship (Prairie Cluster LTEM plant community data, WICR, Bloody Hill).

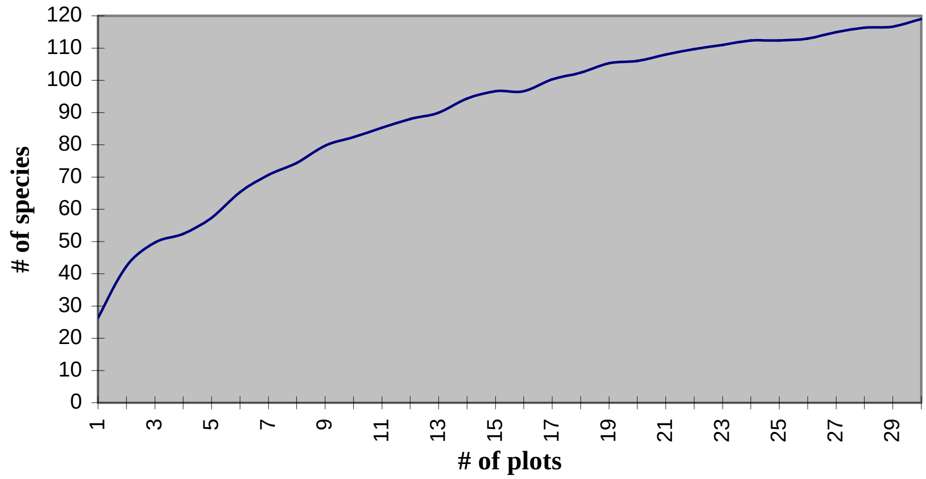


Figure 4. Example of variance in the estimate of mean cover as sample size increases (Prairie Cluster LTEM plant community data, WICR, Bloody Hill shrub cover).

In addition to documenting the occurrence of vertebrate and vascular plant species, a secondary purpose of species inventories is to develop insight into species-habitat associations. The Chihuahuan Desert Network will require that standard habitat attributes be collected for all vertebrate and vascular plant inventories. This will provide a common context for species inventories and will facilitate the integration of species occurrence data across habitats and taxa. It will also provide opportunities to refine and extrapolate species-habitat models from inventory data.

In order to meet this goal, a standard terrestrial data sheet will need to be developed. The resulting habitat data sheet will include basic location data, site environmental characteristics, and vegetation attributes consistent with the National Vegetation Classification Standard (NVCS). The description of vegetation attributes will be consistent with NVCS in anticipation of vegetation maps being developed for the parks (through NPS/USGS Vegetation Mapping Project). This will provide a powerful tool to link inventory data to vegetation maps. We will also develop a standard habitat data sheet for aquatic habitats. Once hired, the network I&M coordinator will be tasked with completing this data sheet.

Survey Methods:

Methods must be both precise (consistent over time) and accurate (correct in defining the state of the resource unit measured). The methods used must be able to accurately evaluate the status of a resource so that trends in the condition of that resource may be detected. High quality inventories must be conducted in order to establish an effective baseline, recognize resources of special concern and establish thresholds for future monitoring efforts.

Survey methods are taxon-specific. Both temporal and spatial factors and life-history characteristics of each species must be considered when conducting the surveys in order to maximize the number of species encountered. In this section, we describe the general methods we will use for each major taxon and for individual species or groups of species requiring special techniques. For all taxa, methodology may be modified to meet specific needs of a project and will be addressed in that project. When possible, inventory protocols within each taxon will be standardized according to the standards described above, so that data can be compared and analyzed on a network-wide basis, and so that broader inferences may be drawn from data collected. In addition, we outline the appropriate timing of surveys.

Bird Methods

The Chihuahuan Desert Network will focus inventory efforts for birds on key habitats of management concern. These habitats (riparian/wetland, high-elevation, grasslands) either support rare or declining bird populations (e.g., black-capped vireo), are increasingly limited due to misuse or ecological disruption (e.g., water diversion in riparian areas and exclusion of fire in grassland habitats), or have been historically under-sampled by the birding community (high-elevation shrub habitat). The goals of the network will be to determine species richness, relative abundance, density, and distribution of birds in targeted areas. The top priorities are: 1) to survey riparian and wetland areas during the spring migration and breeding seasons, 2) survey high-elevation park areas during the breeding season only, and 3) survey grassland habitats during the winter season.

One of the main goals of the inventory is to detect changes in population size and community composition over time. Therefore, we will use distance sampling to both document the occurrence of most species of birds and establish a baseline from which to detect trends in population sizes (or densities) over time. In particular, we will use Variable Circular Plots (VCP; Reynolds et al. 1980) for most bird surveys, but we will occasionally use line transects (Buckland et al. 1993). Distance sampling applied to VCP and line transect surveys may be used to determine differences in detectability of species, ensure consistency over time and space, and generate data that is comparable to data collected in past inventory and research efforts that utilized point count methods (Fancy and Sauer 2000).

VCPs will be at least 250 m apart to help ensure independence of points (Reynolds et al. 1980). We will spend ten minutes at each point. This is longer than the average point count (generally five to seven minutes), but detecting the maximum number of species is our most important goal. However, to ensure that individuals are not counted more than once (a typical problem with longer counts), between the seventh and tenth minutes we will record only new species detected. Surveys for breeding birds should be conducted on four occasions, spaced throughout the breeding season, following the protocol of Ralph et al. (1995). Surveys for breeding birds will begin one-half hour after sunrise and be completed by mid-morning. Migratory birds will be surveyed four times (twice during spring migration and twice during fall migration). Wintering birds also will be surveyed on four occasions. Due to the potential difficulty of detecting non-breeding birds, we anticipate that migrant and wintering bird surveys may require additional afternoon visits for the purpose of identifying species that may not be active early in the morning. General guidelines for data collection, data forms, and field training will follow the "Recommendations for Sampling Birds using Variable Circular Plot Counts: Field Tips, Training, and Data Forms" (Fancy 2000).

No one method of sampling will work for all species of birds. Therefore, we will take into account the general life-history characteristics of different species, through the use of alternative methods for some species. Although occasional observations of birds such as diurnal raptors and goatsuckers are made during VCP and line transects, several taxa require modified or specialized survey methods (e.g., nocturnal species). Therefore, we will use tape playbacks (Fuller and Mosher 1987) for rare species or those not likely to be observed during VCPs or line transects. These include owls, goatsuckers, rare passerines (e.g., yellow-billed cuckoos), and species that occur in low densities (e.g., hawks). Surveys using tape playbacks will be conducted either following regular standard survey counts, or separately from them. Finally, we will scan cliffs for ravens, swifts, swallows, and raptors such as falcons, golden eagles, and vultures.

Distance sampling can be difficult for inexperienced observers; underestimates or overestimates of distances to birds can lead to inaccurate density estimates (Buckland et al. 1993). To help ensure that observers are trained properly, we will budget for five days of training at the start of each field season. During that time we will familiarize observers with the technique, conduct test trials, and have observers compare results. We believe time and money spent on proper training is crucial for producing high-quality data.

Species richness will be calculated as the number of species detected. Estimates of species richness based on mark-recapture models will provide an estimate of the number of species that are probably present, but have not been detected (Dawson et al. 1995, Boulinier et al. 1998). These species richness estimates will be used to assess the adequacy of sampling technique, by comparing the estimated number of species in an area to the actual number counted during surveys (Swann 1999).

Relative abundance and density of each species with >50 detections will be estimated using program DISTANCE (Thomas et al. 1999). The distance data will be used to model detection functions, from which we can obtain unbiased estimates of abundance for each species (Buckland et al. 1993). The advantages in using Distance Sampling data include: 1) multiple surveys can be combined to increase sample sizes. By combining surveys, it is possible to estimate densities of many rare species, even in situations where only 1 or 2 birds are detected while sampling many stations. 2) allows for adjustment of different covariates such as observers, vegetation, and detection distances. And 3) ability to use historical unadjusted point count data. Analysis of data derived from call playback surveys will be limited to estimations of density. Likewise, cliff-nesting species will be described on basis of direct estimation of nesting pairs or colonies and colony size estimations.

Fish Methods

Fish surveys will employ a combination of electrofishing, seining, and dip-netting to sample fishes. When used in combination, these capture methods have been shown to provide a more accurate representation of fish assemblage structure in streams than either method used alone (Dauble and Gray 1980, Onorato et al.. 1998, Schultz 2000). Where appropriate due to lentic or lotic systems, sampling points will include littoral zones within close proximity to extensive cover, littoral zones largely devoid of cover, and offshore benthic and limnetic zones.

Block nets will be deployed at the lower and upper ends of each stream segment sampled to prevent fishes from entering or leaving the reach during sampling. Electrofishing of each site will be conducted using backpack or boat electrofishing gear, depending on stream size. Seines may also be used in habitats not easily sampled with electrofishing gear. The number of electrofishing units used per site will depend on stream size. Two passes of electroshocking per segment will be suitable for inventories. Sampling effort can be quantified using electroshocking seconds. Sampling will be conducted during low-flow conditions in late spring-early summer and/or late summer-early fall, which will maximize efficiency since water volume is typically lower at this time and fish are easier to capture. This sampling schedule will allow characterization of the stream fish assemblages before and after major seasonal disturbances (i.e., summer drought and flooding during the monsoon season) common to streams in the Southwest. The spring sample should also allow characterization of the magnitude and timing of the initial addition of young-of-the-year native fishes.

We will record species and the number of fish caught per species (relative abundance) at each location. Health is a priority; handling of fishes will be kept to a minimum and sampling will not occur during periods of elevated water temperature (Kelsch and Shields 1996). This is especially important due to the possibility of encountering federally and state listed threatened and endangered species. Fish captured during each pass will be maintained live until completion of sampling. Fish will be released alive except as provided for in each individual scope of work. It was identified that some fish species may need tissue samples for genetic analysis. This will be addressed on a case by case basis in each scope of work. Voucher specimens may be necessary in the following cases (subject to National Park Service approval and as determined by each park's resource management staff):

1) Voucher specimens and/or voucher tissue samples may need to be retained of those individuals not readily identified on site.
2) Voucher specimens and/or voucher tissue samples may need to be retained for target species, as identified in each project.

Mammals Methods

The goal of the mammal inventory for the CDN is to establish current baseline documentation of small mammals and bats, with incidental (ancillary) data to be collected on medium-sized and large mammals. Sampling strategies may vary depending on the park terrain and the species or groups of interest. The exact number and distribution of survey points will be established upon further refinement of a network-wide sampling protocol. When possible, we will conduct inventories at sites selected by stratified random sampling. Stratification will be based on landscape features (e.g., slope, soil type, elevation) or vegetation associations where feasible. Areas that are remote, logistically challenging, or sensitive will be excluded from selection, but may be sampled in a limited way as required for the documentation of species of concern. Some locations in the park (e.g., cliffs, riparian areas) may require focused inventory efforts in order to detect species that are habitat-specialists or those that occur in very limited geographic areas. Such areas should be identified and evaluated for the feasibility of "unequal-proportion" sampling.

In parks where a history of inventory work exists, we will attempt to avoid unnecessary duplication of sampling effort. Priority will be placed on areas that have received less attention. If possible, inventory plots will be chosen with an eye toward the establishment of long-term monitoring sites. Most work will be done during the summer season, but modifications to the schedule may be made as deemed appropriate. The extent of work to be conducted at other times of the year will be determined by the logistical concerns and inventory needs of each park. General inventory methods will follow guidelines described in Kunz (1988) and Wilson et al.. (1996).

Comprehensive bat inventories will require specialized techniques involving both indirect (ultrasonic bat detection, roost observation) and direct (mist netting, telemetry) survey methods (Kunz et al. 1996, Jones et al. 1996), as well as highly trained personnel. Where roosting sites are known or suspected the sites will be observed without disturbing the bats, in order to prevent potential disruption of maternity colonies. Roosts can be selectively netted from the outside to identify species, or cameras may be set up outside the entrances. At parks where bats are not readily captured, we will develop walking transects to search for bat presence based on observations of guano and insect remains, or by audible and identifiable echolocation calls.

All water sources larger than 1 meter will be included in the list of “unequal-proportion” sampling sites, and mist nets should be employed to capture bats at these sites. Where no water sources are available, experienced personnel will deploy nets at sites they determine to be likely flyways. Suitable sites will be netted two to three times during the summer season, but no more often than every four or five days, depending on past success rates. Effort with mist nets will be quantified based on size and numbers of nets set each night (net-nights). Sex, reproductive status, age, and species will be recorded prior to the release of captured bats. In some cases it may also be useful to record body mass and/or selected measurements. Photographs will be used whenever possible for species documentation, and will be supplemented by necessary voucher collections (subject to National Park Service approval). Personnel handling bats will be vaccinated against rabies using the rabies pre-exposure regimen with subsequent testing of rabies antibody titers.

In areas with limited roost sites or water sources, it may be necessary to use a bat detector to determine bat presence. Sample points or transects can be randomly selected and both species diversity and relative activity levels can be determined at a pre-determined number of points along the line. Most North American bat researchers use the Australian bat detector Anabat, made by Titley. Due to some questions regarding the use of bat-detector transects (O’Shea and Bogan 1999), we recommend that their use be restricted to situations where Anabat is required to identify or confirm bat species occurring in the park.

Small and medium-sized rodents (including ground squirrels) are effectively trapped in livetraps such as those made by Sherman, or wire traps such as those made by Tomahawk and others, and can be released unharmed following identification (Jones et al. 1996). At this stage of the inventory effort the priority is obtaining accurate information on species richness; we, therefore, anticipate that livetraps will be set out in lines of 150 meters in length with starting points randomly determined. We will use two traps per station and stations will be spaced at 15-meter intervals along the line. Additional lines will be spaced at equal intervals, but landscape complexity may require shorter intervals in some cases. Traps will be set for three nights, checked twice a day, and closed during daylight hours except during periods of trapping effort directed at diurnal species, when they will be checked hourly. Where possible, livetraps will be set at habitat features (e.g., logs, trees, burrows) located within 2 meters of the station point. Traps will be dug in and covered with soil and vegetation to protect animals from temperature extremes. Effort and catch will be quantified based on the number of nights a given number of traps are set (trap-nights).

Kill traps are effective for species that are reluctant to enter box-style traps and are useful in logistically difficult areas such as cliffs where it may be difficult to set out a sufficient number of box traps. In selected areas and for selected species, “snap” traps may be used, and to the extent possible, kill traps (e.g., Museum Specials, Victor rat traps) will be set in a fashion consistent with livetraps described above.

Standard measures (weight, combined head and body length, hindfoot, tail and external ear length) will be taken on all individuals captured. General body condition and reproductive status will be assessed. All information, including exact location of capture, will be recorded on a standardized data collection form. Individuals will be identified to species, gender and age-class to allow for demographic comparisons. We will trap for two consecutive nights at each location. Photographs will be used whenever possible for documentation, and supplemented by necessary voucher collections. Subject to National Park Service approval, tail biopsies or toe clippings may be used for voucher specimens or to confirm identifications. All rodent trapping will be consistent with published guidelines for reducing exposure of trapping personnel to hantavirus and other infectious diseases.

A few mammal taxa require specialized techniques due to their unique life-history characteristics. Shrews, for example, are very difficult to locate and are rarely captured using live-traps. Shrew biology should be considered when establishing trapping locations, as most *Sorex* species prefer more mexic, litter-rich sites. We plan to search for shrews in appropriate habitats by turning cover and raking leaf litter, and effort will also be put into pitfall trapping. Small plastic cups and buckets have proven effective as pitfall traps for shrews (Jones et al. 1996). In suitable habitat, we will install pitfalls at 5-meter intervals, with special care to avoid impact to cultural resources. Where possible, we will operate pitfalls with drift fences, and pitfalls will be unbaited, kept dry, and checked frequently to prevent harm to the animals. Pitfalls are also effective at capturing some small heteromyid rodents, such as pocket mice, and will therefore be used in suitable habitat. Trapping effort and catch will be quantified for each area based on the number of nights that a given number of pitfalls are operational (pitfall-nights).

Medium-sized and large mammals will be documented mainly through opportunistic sampling methods, such as night-driving surveys, collection of roadkills, surveys for conspicuous dens (for beaver, gopher, squirrels, etc) (Wemmer et al. 1996), documentation of track, scat, sign, and incidental take in live traps. Where appropriate, hair traps or infra-red triggered cameras may be set up at locations near sample points. In the event that individual species are determined to be of concern to one or more parks in the network, specific techniques applicable to those species will be implemented.

Plant Methods

The survey protocol for plants will follow the stratified random sampling approach as described by the Northern Colorado Plateau Network. Releves will be permanently established in preparation for potential re-sampling during the monitoring phase of the Inventory and Monitoring Program.

Due to the variable climatic conditions required for plant species to germinate, and because the propagules of many plant species can remain dormant for years, inter-year and inter-seasonal explosions of species diversity can occur. Although multi-seasonal and multi-year surveys provide the most complete inventory information, we anticipate that funding will limit the Amistad survey to one month in the late-spring/early-summer, and one month in the late-summer/early-autumn of a single year.

The exact number and distribution of survey points will be established upon further refinement of a network-wide sampling protocol. Once a sample point is selected, we will use a combination of releves (Mueller-Dombois and Ellenberg 1974) and area searches to classify and describe the general habitat characteristics, and to sample the vegetation, around each point. Although this approach requires more time and more experienced botanists than some alternate methods, it will provide a more complete baseline inventory.

The releve system requires choosing representative areas within the plot (homogeneous) and recording plant taxa with neighborhood attributes. If a sample area is a mosaic of several distinct changes in plant taxa and habitat, the area may require several releves to completely describe. The releve approach will identify dominant and co-dominant plant species of an area, along with common to rare associated species. The use of a releve to describe the vegetation at each sampling point will also allow for direct comparisons between parks of floristic and vertebrate survey data. In addition, the use of a standard releve size means that species-area curves can be calculated for floristic species richness estimates. Because of the value of doing vegetation description, we will require all inventory teams to use some type of releve form appropriate to the region for documenting dominant species (similar to the CPVAC form described by Rowlands (1994)), to describe the vegetation at each sampling point. Our suggested approach is to complete an abbreviated releve (for 5-7 dominant species), which will require less time than a full releve.

The area around the sample point will be searched in a back-and-forth sweep pattern to exhaustively sample all plant species occurring there. Unique areas such as mesic microhabitats, riparian stringers, and rock outcrops within each elevation gradient will also be surveyed. Subject to National Park Service approval, unidentified species will be collected and processed for later identified and addition to the inventory species list.

Reptiles and Amphibians

When surveying for amphibians and reptiles, it is critical to consider seasonal patterns of activity. Although some species are more active in spring when temperatures are cooler, the majority of herps in the desert southwest increase their activity during the summer rainy season. Therefore, we will conduct surveys during both late spring-early summer (May-June) and late summer (August-September). All surveys will be conducted by teams of qualified herpetologists and will follow the progression of seasons, from southern to northern parks, and from low elevations to higher elevations. The exact number and distribution of survey points will be established upon further refinement of a network-wide sampling protocol. Care will be taken to ensure independence of survey points within each sampling framework, and survey points will be established with an eye toward future monitoring efforts.

We will use a variety of methods to survey for amphibians and reptiles. The most common visual encounter survey, time/area-constrained searches (TACS), will be used to survey for a wide variety of species. This technique requires that an area of known size be thoroughly searched using a variety of techniques, including scanning with binoculars, using mirrors to shine into cracks in search of hidden reptiles and amphibians, and looking underneath cover (Crump and Scott 1994, Rosen and Lowe 1995). At each sample point, we will establish three one-hectare plots, and two herpetologists will rotate search efforts through the three plots to reduce observer bias. Each plot will be surveyed twice per sampling period, and surveys will be limited to two-hour periods (not including time for processing captured amphibians). Because observers vary in their ability to detect reptiles and amphibians, we will attempt to further reduce observer biases by calculating the number of animals observed per unit effort, which will enable us to estimate individual differences in detection abilities.

We will construct pitfall arrays (Gibbons and Semlitsch 1981) in areas where we can dig easily, such as soil terraces in washes. Special care will be taken to avoid impact to cultural resources. It is expensive and impractical to construct pitfall arrays at all sample points; therefore, we will use them primarily in lower elevation washes and terraces. These arrays will allow us to sample fossorial species that are rarely encountered during visual surveys.

We will conduct night-time road-cruising surveys to sample nocturnal species such as snakes and toads (Shafer and Juterbock 1994) and night-time surveys at ponds or other sources of water by spotlighting, and by listening for calls. Time and distance covered during a road-driving session will be standardized by driving at a constant speed for a variable time, depending on availability of road to drive. Road-driving should be done with 2 people, driving at 20 mph; to avoid fatigue, no more than 2 hours of night-driving should be done on a given night, especially if crews have been surveying during the day as well. For most parks, all paved road should be driven, for some, there may be more road than can be covered on a single night in 2 hours of driving. In these parks, night-driving should be done on consecutive nights until all roads have been driven. For all driving surveys, it will be necessary to drive the route during the day, either before (preferred since this allows surveyors to become more familiar with the routes) or after the night survey. The daytime drive will be used to record what habitats are traversed, and length of transects in each habitat.

Methods described in the Amphibian Research and Monitoring Initiative (ARMI), which is a national effort funded by Congress starting with the FY2000 Department of the Interior (DOI) Budget, will be used where applicable. Many of these techniques have been tested in other parts of western North America, but will need some evaluation for effectiveness on the Chihuahuan Desert Network.

Visual Encounter Surveys (VES) or similar systems that have proven reliable to detect pond amphibians (Fellers and Freel 1995, Corn et al. 1997, Bury and Major 1997, Olson et al. 1997, Adams 1999) will be used to survey for amphibians at ponds, tinajas, and other lentic habitats. These studies suggest that two VES per season are needed for detectibility of species presence and include a spring search (best for locating egg masses) and one later in the summer (time to locate tadpoles and larvae). Standard and field proven data forms are available to record basic habitat variables (e.g., pond size, substrate type, vegetation, etc.), but have not been tested in arid and semi-arid environments.

For toads and some frog species, we will listen for vocalizations associated with breeding aggregations (Rosen and Lowe 1995). The timing of this sampling effort is critical because many species will aggregate for only a few nights during the summer rainy season. To locate these aggregations, we will drive roads and walk washes. This effort will be enhanced by mapping known water sources in parks and sampling them after the first monsoon rains. Field workers will be trained in anuran vocalizations identification using commercially-available tapes.

Calling surveys, in the form of audio strip transects (Zimmerman 1994) will be conducted during the spring breeding season, and if males are calling during the monsoon season in July and August, these surveys will be repeated. Audio strip transects will be run along the shores of permanent and intermittent stream channels for up to 500 m, depending on available habitat. Calling surveys will also be conducted at lentic habitats (e.g., ponds, tinajas, potholes, and isolated pools in washes following spring rains and flash floods).

Egg mass and tadpole surveys will also be conducted in the same habitats as the calling surveys. Detection of eggs or tadpoles will be used both to directly identify species' presence where this can be determined from egg mass or tadpole characteristics and to identify locations to be targeted in subsequent surveys when metamorphs are available for identification. Both egg mass and tadpole surveys can provide assessments of reproductive effort, and coupled with later counts of metamorphs can yield estimates of survival rates in selected habitats, which could be incorporated into a monitoring program.

Sound-activated recording devices will be used experimentally in a few areas to determine whether these can be used to detect species presence during breeding calling periods in a number of sites, since it is very difficult to mobilize adequate numbers of personnel to visit large numbers of widespread potential breeding sites within a day of an appropriate precipitation event (e.g., heavy thunderstorms), the area extent of which is uncertain, thus it may not be clear, even if mobilized successfully, where technicians should be sent.

The use of drift fences around ponds can also be valuable, although it requires that the traps be checked at least every couple of hours at night, simply to avoid the animals dying and drying out.

Amphibians can be netted, or caught by hand (care should be taken to clean hands after collection since there are toxins released by glands in the skin of most amphibians). Most species that live in the southwest are burrowers, only coming out nocturnally. Daytime heat and dryness will cause death in a matter of minutes if precautions are not taken. Once collected, if the animals are not going to be immediately photographed and released, they should be placed in a wetted collection bag and are best placed in a chest that that has ice in it. The ice should be bagged and insulated from direct contact with the bags containing the animals using other bags, polyfoam, etc. All amphibians and reptiles encountered will be identified to species, sex, and age, as possible. Encounter locations will be pinpointed to the nearest 0.01 mile using calibrated vehicle odometers.

Documentation of reptiles will occur primarily through opportunistic sampling that occurs in conjunction with amphibian inventories, and may include night-driving surveys, photography of individuals sighted, and incidental take in amphibian traps. The primary tools for collection of reptiles are a good set of tongs (e.g., Pillstrom), a “potato rake (hoe)” with hardened steel tines for turning over rocks, etc., good headlights, special double stitched “snake bags”. The methods of collection can range from road hunting from a vehicle, working around the collection sites by foot and turning over rocks, trees, etc., or use of a drift fence and traps. If the latter are employed, it is essential that the animals not be left in traps for more than several hours, as death will rapidly ensue. Once collected, if the animals are not going to be photographed and released immediately, it is best to keep them in an ice chest as described above for amphibians.

Possible Ancillary Evidence

Investigators doing amphibian and reptile surveys may have an interest in collecting additional information concurrent with baseline inventory work. For some, it is customary to collect blood samples, tail clips and toe clips to obtain DNA and other evidence. While the CDN supports these efforts, they are mostly beyond the scope of this inventory project. It is the policy of the CDN that collection of these kinds of samples will be permitted on a park by park basis. Each park will determine the acceptability of this technique based on in-house collection policies. The costs of this sampling and analysis must be absorbed by the investigator and will not be provided for as part of routine inventory projects.

When permitted, the following standards would apply. Since all vertebrates other than mammals have nucleated red blood cells, whole blood serves as an excellent source of DNA and proteins. Blood can be collected directly from the heart on large animals (most adult ranid frogs) using 1-ml syringes and small (about 25-27 gauge) needles. This procedure involves turning the animal over, watching for the ventricular beat, and collecting the blood directly from the ventricle. It routinely yields up to 0.5 ml of blood from an adult bullfrog, but will allow 0.1-0.25 ml to be collected from virtually all other anurans. This should be placed in a microcentrifuge tube with the correct amount of anticoagulant (see below). However, most samples earmarked for molecular studies will be collected using “tailclips” or “toeclips”. These can be easily collected and the clipped toes often serve as a good secondary identification for animals that have also been marked with tags. Clipped toes should be wrapped in tin foil and frozen on dry ice or in liquid nitrogen as soon as possible.

For many of the amphibian and reptile (and even other vertebrate) species that we anticipate will be collected, a basic understanding of relationships among wide-ranging is lacking. Using toe clips or blood collected without harm to the animals as sources of DNA (or organ tissues from voucher specimens), we will employ PCR-based sequencing analyses for several genes found in mitochondrial DNA (based on amplification of consensus primers already in use in several of our labs), as well as powerful new fingerprint analyses such as AFLP (Vos et al. 1995). Using this battery of molecular techniques, we will be able to generate genotypes for individuals that can be used for future comparative work, analyze phylogenetic relationships where questions exist about forms found in the different parks, and where sample sizes permit estimate population diversity and structure.

Tail blood is easily collected from larger lizards. Details are presented below. Essentially, the animal is turned over and the midventral region of the tail identified. The 1.0-ml syringe with a 25-26 gauge needle (0.5-1. in long) is inserted vertically (see below) until the spinous process of a caudal vertebra is touched by the tip of the needle. Then the needle is pulled back a bit until the sinus is located. Again, It is best to observe an experienced researcher before trying this alone. Blood is treated as for heart puncture. Toe clips that have been removed or tips of tail that have been lost can be frozen quickly as described above.

E. Data Management and Analysis

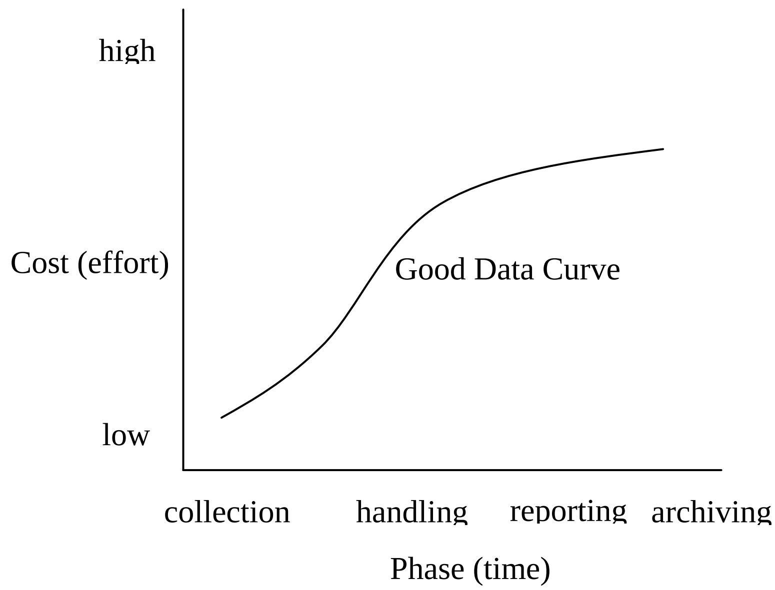
Implementation of the Natural Resource Challenge represents a watershed for the stewardship of natural resources in the NPS. The recognition that better information is needed to effectively manage our natural resources has resulted in greater emphasis, increased funding and re-invigorated support. The quality of the information we gain from this initiative will ultimately be determined by the quality of the data from which it is derived. Therein is a tremendous responsibility for the NPS -- to manage the influx of data so as to insure its quality and integrity. Success will be evidenced by quality data that provides reliable information to today's managers and to their successors. To do so, proactive data management must be an integral part of each inventory and monitoring project to insure the data do accurately represent the "truth", and that the "truthfulness" of the data is verifiable.

"A lot of information may be based on good data, but much is not. Good data, however, is always based on the truth" (Steven Tessler, NPS Draft Data Management Plan, 1995).

Data management is a priority for the Chihuahuan Desert Network; the network is in the process of transferring most existing inventory data into NPSpecies for verification. Continued dedication to data management is exemplified in the data management standards and principles presented below, and long-term data management needs will be met by a permanent data management position funded through monitoring funds.

The role of data management should be emphasized in the process of data collection and handling. Attention to data management early in the sampling and data handling process, targets resources where they have the greatest potential to control data quality (Figure 5). Further, by focusing on collection and handling, the work of the Chihuahuan Desert Network may contribute to the larger data management efforts by supplementing existing information and tools. The objective of this document is not to define specific field names or table structures; rather to describe key elements that will form minimum standards for agreements and the framework for the Chihuahuan Desert Network data management system. The core components include: 1) standardized data fields to promote relatedness among data; 2) data verification and validation requirements including minimum accuracy standards; 3) a database design that utilizes table relationships to maintain referential integrity between data and metadata; 4) a system design that encourages data exploration through inter-relating data through time, space and taxa; and 5) a long-term data archival strategy.

Figure 5. The hypothetical cost of assuring good data quality at various stages of inventory completion.



Data management is often thought of as an exercise conducted with computers. However, data management responsibilities begin with data collection. During the collection phase, data management activities involve: 1) building relatedness among data sets through standardized field forms, site and event codes, and habitat measures; 2) assuring field activities are well documented; 3) facilitating accurate implementation of sample methods and collection of complete data; and 4) establishing measurable minimum standards.

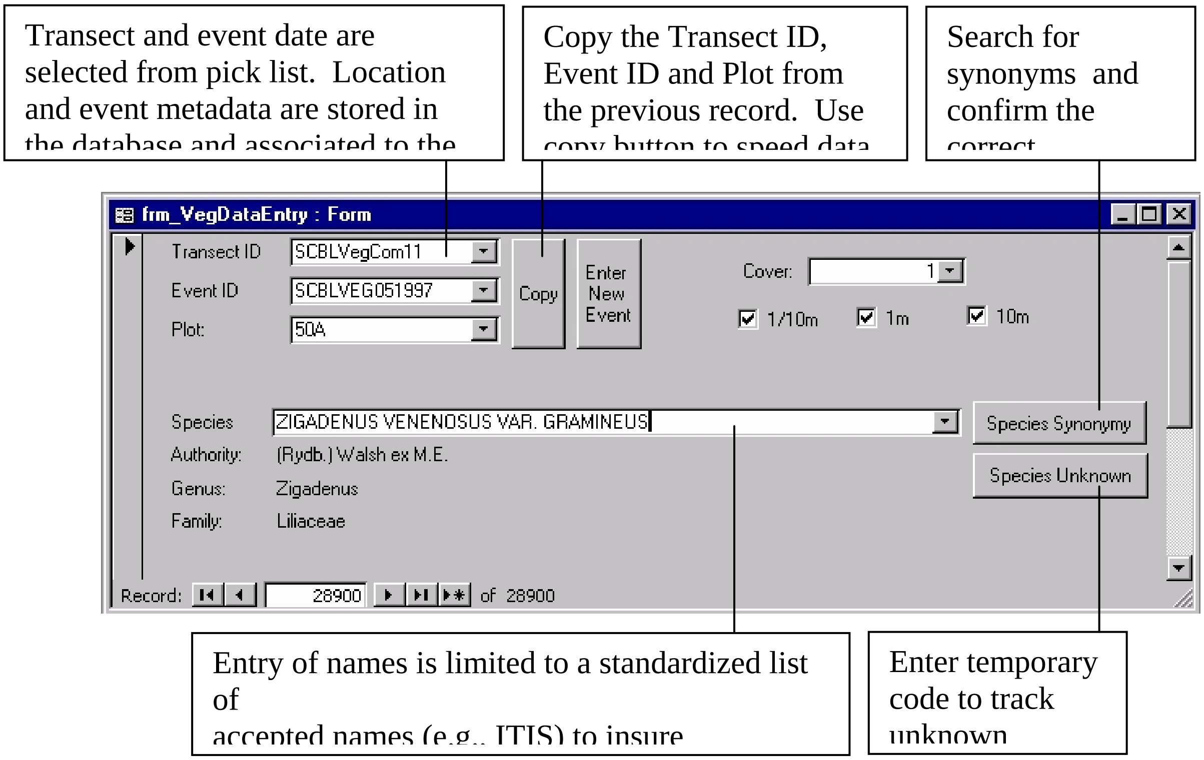
For the data to be fully utilized, relatedness among data sets must be designed to accommodate unforeseen needs. A standardized habitat worksheet will be used for all inventories to document the strata. The worksheet will be a powerful tool for two reasons. First, information in the worksheet is flexible to accommodate changing strata and classification systems through time. Second, investigators will be able to define search criteria based on the worksheet, and can identify all data sets across time, space and taxa of interest through database queries. Finally, the network will assign standardized event/site codes, and develop standardized field forms for all inventories.

The Chihuahuan Desert Network will require investigators to document the standard operating procedures used during the course of the study. Documentation should describe step by step the procedure used for data collection, including any modifications or adjustments made to accommodate field conditions, the precision of instruments, etc. While network personnel cannot monitor every field trip and observe the sampling techniques, we will take proactive steps to encourage accurate implementation of sampling methods. Network staff will develop abbreviated methods and look up guides for field crews that summarize critical components of the sampling methods. To facilitate complete data collection, standardized data forms that cue investigators to record pertinent data in an appropriate sequence will be developed. Where appropriate, the Access databases will include standard “report” formats for printing field forms, complete with sample site coordinates and attributes**.**

Finally, each scope of work will establish minimum requirements regarding how much of the fieldwork must be done by the principal investigator (i.e., as opposed to graduate students or others). The Chihuahuan Desert Network will require submission of resumes from all individuals involved in the project. Any substitution in personnel will require prior approval by the Inventory Coordinator.

The process of transcribing data from field forms to digital format inevitably introduces error. During the data-handling phase, data management activities focus on: 1) designing tools for data entry that reduce transcription errors; 2) independently verifying data transcription; and 3) developing data error-trapping techniques. Chihuahuan Desert Network staff will design data entry forms that screen or prevent erroneous values by using pick list and value limits for protocols that will be repeated as long-term monitoring (e.g., plant community), or for inventories repeated in several parks (e.g., herpetofauna). For example, Figure 6 demonstrates quality control features of the plant community data entry form.

Figure 6. Example of plant community monitoring Access data entry form.



Data verification is the process of comparing the data as in the database to the original field forms. The principal investigator is expected to compare 100% of the data to the original. The network will require original copies of all field data sheets from the investigator and randomly select a sub-sample of the data to compare to field data sheets. A minimum of 95% accuracy is expected. A description of verification procedures and results will be included in the metadata.

Data entered into the database may accurately represent the field forms but yet be erroneous. The Chihuahuan Desert Network will employ several strategies to validate data. First, all agreements and scopes of work will include minimum identification accuracy standards (e.g., 90% for plants, 98% for vertebrates). To determine compliance, a second individual or NPS personnel will review a subset of voucher specimens for accuracy. Second, Chihuahua Desert Network staff, in collaboration with the principal investigators, will develop lists of potential values (e.g., pick list) or acceptable ranges for values (e.g., temperature) for all data fields. These limits will be built into the database tables and used to flag potentially false records. Finally, staff and principal investigators will develop criteria to capture logical errors (e.g., a tree with a height of 100 m and a dbh of 1-inch). The criteria will be used in queries to identify questionable records, and recorded for use as new data is added to the database.

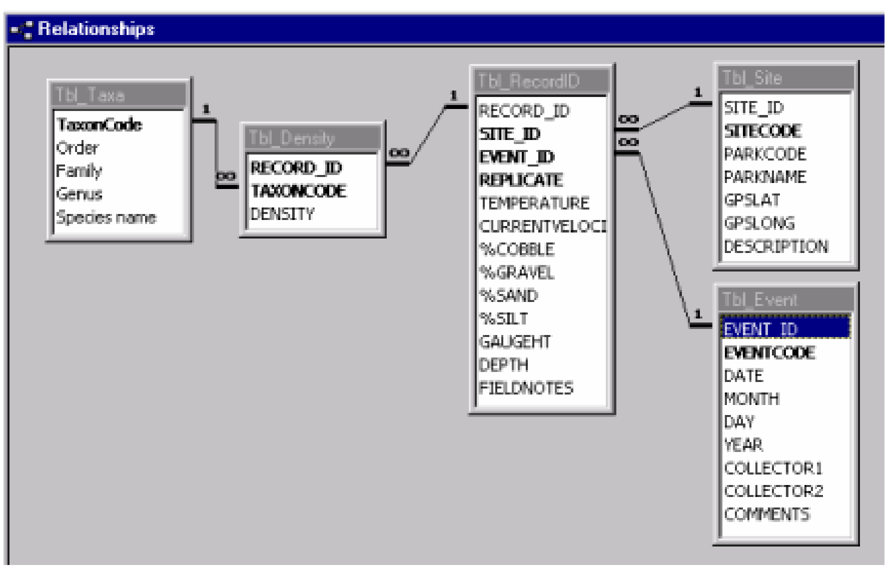
All spatial data products will be compatible to NPS Theme Viewer and comply with FGDC metadata standards. Network personnel will review products for compliance

Database Design:

The Chihuahuan Desert Network will adopt a proactive data management approach that looks beyond the primary purpose of the inventories (i.e. to collect site specific information regarding a taxon) and promotes data exploration by building relatedness among data through time, space and taxonomic group. A centralized Access database will incorporate one shared set of tables used to identify site, event and taxon that are linked to individual data sets. For organizational purposes, standardized site, event and taxon codes will be applied consistently from the field data sheet through the summary report. Tabular data will be associated with related protocols and reports using the NPBib ID number.

Each project will identify the type of metadata required from each principal investigator. In addition to documentation of standard operating procedures, metadata requirements include whom, where, when and the methods employed. Furthermore, metadata should include ancillary information about weather conditions, vegetation phenology, unique situations (e.g., illness, injury, equipment trouble), verification and validation results, data edit log, etc. Metadata is critical to verifying the accuracy of the data and must be intrinsically secured to the data itself. Data and metadata will be linked using database management tools (e.g., key fields, join types and referential integrity). For example, Figure 7 shows the design of an Access database to manage aquatic macroinvertebrate data. Here critical metadata such as site physical characteristics (e.g., percent cobble, gauge height, site location, event information and collector ID) are linked to the actual data (e.g., Tbl_Density).

Figure 7. Example of access database to manage aquatic macroinvertebrate data.



Data Archiving and Dissemination:

Appropriate archiving and dissemination of the data is the final step toward ensuring accessibility to the data and maintaining data quality. Fortunately, servicewide databases developed by WASO I&M are available for this task. The Chihuahuan Desert Network Coordinator/Data Manager will be responsible for incorporating inventory data into the service-wide databases either by including the task in the scope of work or by personally entering the data. The Network Coordinator will be responsible for supervising the data entry of non-NPS personnel and providing for quality assurance (i.e. verify random sample of data.) In addition, final reports and manuscripts regarding the inventory will be entered into NPBib and each dataset will be recorded in the Dataset Catalog. Original field data sheets will be stored in the Chihuahuan Desert Network office, with a copy stored at the park. Copies of digital data, metadata, reports and summaries on CD will be distributed to the parks, Regional I&M Coordinator, and Servicewide I&M Coordinator.

Data sheets will be copied and stored in three locations: with the principle investigator for the project, with the director of inventory for each taxonomic group; and with the field research team. Data will be entered at the end of each field trip or field day. Data will be entered in Microsoft ACCESS or an appropriate database; geographic data will be recorded directly from GPS units. Locations will then be archived and/or plotted on topographic maps of the park using ESRI ArcView© or similar mapping software. Field data sheets will be developed that follow the structure of the databases developed for field inventory work. This will facilitate data entry and error-checking. Alternatively, data will be entered directly into hand-held computers. The database structure on hand-held units will mirror the structure of the project databases, and data will be downloaded to a laptop computer, or otherwise backed-up at the end of each day's field sampling.

Species Distribution Mapping:

Distribution maps will be developed for all vertebrate and vascular plant species at each park based on historic and project field surveys. For common species, distribution will be plotted in Program ArcView using plot GPS locations and presence/absence data associated with each plot. For rare species and species of special concern, presence and absence distribution will be plotted using specific GPS locations. For some special status species, relative abundance or breeding localities may also be mapped.

Wherever possible, we plan to use models based on mark-recapture designs for estimating species richness (Dawson et al. 1995, Boulinier et al. 1998, Nichols et al. 1998, Hines et al. 1999). There are many mathematical models that can potentially describe the rate at which species detections accumulate as a function of area or number of plots. However, virtually all of these models assume that probability of detection is constant among species within and among plots, and among years and seasons. Moreover, the performance of many mathematical models as predictors of species accumulation is similarly highly dependent on the structure (distribution and relative abundance) of the sampled taxa (Keating and Quinn 1998, Keating et al. 1998). By contrast, there are models for estimating population size (i.e., species richness) based on mark-recapture (i.e., repeat detections of species) that can explicitly accommodate differences either in detectability among species or within species over time caused either by changes in community structure or efficiency of detection methods (Boulinier et al. 1998, Nichols et al. 1998, Hines et al. 1999). Indeed, major heterogeneity in detectability of species for these reasons has been documented for birds (Dawson et al. 1995, Boulinier et al.. 1998, Nichols et al.. 1998).

The application of mark-recapture models to the estimation of species richness is described by Nichols et al. (1998) and Hines et al. (1999). These models are available in a software package called COMDYN on the Patuxent Wildlife Research Center web site at http://www.mbr-pwrc.usgs.gov/comdyn.html. The model that includes heterogeneity of detection probabilities (M_h) for estimation of S uses total number of species detected and the numbers of species detected at each sample point, in order. Where the mark-recapture models in COMDYN produce suspect results, we will use Lee and Chao's (1994) theoretically related incidence-based coverage estimator (ICE) as an alternative and check. ICE is available in the EstimateS software package published at http://viceroy.eeb.uconn.edu/estimates (Colwell 1997).

Models for Estimating Inventory Completeness:

Inventory completeness will be determined by comparing the number of species encountered with species richness estimates at different points in time. The number of species encountered as a function of the number of sampling days will be plotted for each taxonomic group in each park. The study design for most inventories proposed in this plan also allow estimation of species richness using mark-recapture methods for sampling closed populations (of species) (e.g. Boulinier et al. 1998, Swann 1999). Determination of inventory completeness will be based on comparison of these two numbers.

For heuristic purposes, we will also compare survey results with two other datasets: the number of species historically observed at the park, and the number of species expected to be present based on range maps at the appropriate elevation. Because many existing park species lists are inaccurate or incomplete, and because appropriate habitat for some species may be absent at each park, this method will be used mainly to guide sampling design and not to determine completeness.

In some cases, species lists are available which are not based on a systematic inventory design. In these special cases it is difficult to determine inventory completeness. To determine completeness, we will compare the encounter rates of undocumented plants to documented ones. Completeness will be based on the mean encounter rates of new (undocumented) species compared to previously documented species. "New" species should make up less than 10% of all species encountered for each strata for the previous inventory to be considered to be 90% complete.

Long-term Monitoring Using Inventory Data:

Data from our inventory effort will be used in long-term monitoring of native species richness and other population and community parameters. Trends in species richness over time can be detected using data from inventories repeated on a regular cycle (for example, every 5-10 years). Trends are most meaningful when comparisons can be made among sets of data collected using similar methods in a number of areas. We will detect trends in species richness using analysis of variance (ANOVA) or similar methods. Similarly, in some cases it will be possible to determine trends in population parameters of species of special concern where in-depth surveys for these species allow us to estimate absolute abundance or density.

F. Products and Deliverables

In order to achieve products that are useful, scientifically intact and defendable regarding methodology, it is also critical to provide protocols and training. The Chihuahuan Desert Network is providing training to its staff in database management, data collection protocols for the field; data processing protocols and methods. Training will continue to be reinforced and provided as the inventory process moves along to insure that all staff is familiar with methods, analyses, data integrity and processes.

The following represent the minimum set of deliverables for the Chihuahuan Desert Network Biological Inventory Project:

1. Progress reports:

   These may be biannual or annual, depending upon the taxa and progress of fieldwork and data compilation. These will be submitted by the principal investigator to the Chihuahuan Desert Network Coordinator/Data Manager for archiving and transmission up the chain (network, park, region, national).

2. Final report:

   Structure of the final report to be determined, but at a minimum it will include summaries of each of the taxa, field work and inventory/metadata of materials and information submitted to the Data Set Catalog and NPSpecies. Bibliographic information will be updated into NPBib and the ANCS+ catalog records will be updated. If required, this information (excluding sensitive data) will be available in a format to upload to the NPS Website. GIS products will conform to the Inventory and Monitoring specifications for the ArcView GIS data browser extension. Reports will be submitted in MSWord format.

3. GPS data:

   Minimal data/products from GPS collection will include original rover files, base files, differentially corrected files (where applicable) or original files with RTCM included, on diskette, zip drive, or CD. Standardized metadata for all field collections will be required. Products of the GPS data will include ArcView Shape files, graphics and derived products in various formats depending upon user, need and audience. Metadata about this information will be available to upload into the Dataset Catalog.

4. ArcView GIS themes and Microsoft Access databases:

These will be developed from the field data collected and the historical records and documents incorporated into databases and made available. Attribute field data for the various taxa will be entered into a relational database by the survey team. Preliminary QA/QC will be done by the field crews, reviewed and approved by the principal investigator. Upon approval, this material along with associated field records, documents, maps, raw data, photographs etc. will be transferred to the Chihuahuan Desert Network Coordinator/Data Manager via network and electronic format.

Data for all parks will be archived and managed by the Chihuahuan Desert Network Coordinator/Data Manager, who will ensure that each park has a copy of all data related to that park. Relational database files will be developed for all parks that are ready for ArcView. ArcView themes, coverages and shape files will use version 3.2 for Windows as a minimal platform; likewise the Access databases will be on the most current platform and version. Database care, maintenance and feeding will be accomplished according to the directives of the Coordinator/Data Manager. Hiring of support staff will be dependent on budget and workload. Until the actual surveys get underway, estimating database management workload has been a challenge.

5. Storage/Archiving:

Archiving and storage of original field data and derived digital products will be the responsibility of the Network Coordinator/Data Manager. Electronic storage of materials via CD, zip disk and diskette will be implemented. Security for information and protocols for intranet security have been established via protected passwords and multiple tiers of access to records, databases etc. Backup protocols for data and information will be implemented, including secure, off-site storage for all information electronically, due to potential hazards (geological, fire).

6. Linkage with NRID Inventory and Monitoring Databases:

It is critical to bear in mind that data from the biological inventories will be maintained in various databases and formats. The linkages between the major databases, including the permits database will be critical to making the information available to the widest audience and widest range of uses. The primary linkages between the Dataset Catalog, the NPBib, the NPSpecies and the permits database will allow query, evaluation, analysis and, in the long term, linkage to other critical pathways such as Synthesis, the Investigator's Annual Reports Database; the Blue Angel Gateway to move information to the WWW; the Voyager Library Database and the Park Profile databases launched from the NPS Web pages. In turn, the availability of this information will strengthen and serve to sustain the Natural Resource Challenge.

-NPSpecies: Updates for all parks will be done by the staff of the Chihuahuan Desert Network, or by the Network Coordinator/Data Manager.

-ANCS+ (Automated National Cataloging System): All parks participating in the Chihuahuan Desert Network have access to the ANCS+ software and database system.

The update process for collections related items (voucher specimens, photographs etc.) will be handled through cooperation between the Resource Management and Collections staffs in the various parks and the Network Coordinator/Data Manager.

-NPBib (National Parks Bibliography): Ongoing updates to this bibliography will take place as materials are reviewed and records created. ProCite software serves as the standard platform for this bibliography. All parks in the Chihuahuan Desert Network have access to this software, and to the new web based version of NPBib. Entries may be submitted by teams and their principal investigators or an annual update can be supervised by the Network Coordinator/Data Manager.

-Dataset Catalog: This catalog has recently been launched – information for this catalog or park holdings and associated metadata will be updated and maintained by the Network Coordinator/Data Manager as field information is collected, checked and processed.

-Metadata (FGDC compliant): A short form has been developed for use by the Intermountain Region parks by the Intermountain GIS support staff. It incorporates the minimum number of fields and information required to generate FGDC compliant metadata about any project. This form will serve as the absolute MINIMUM data which will have a collection requirement by any team gathering data related to the Chihuahuan Desert Network project. Support and assistance for complying with metadata standards is available through the Intermountain Region GIS Office in Denver.

7. Database updates and maintenance:

Updates and maintenance of the park specific databases will be coordinated through the Network Coordinator/Data Manager utilizing current staff. Individual parks will transmit data to the Network Coordinator/Data Manager, who will be responsible for overseeing upload, upgrading of databases, and permanent archiving.

III. COORDINATION AND LOGISTICAL SUPPORT

The success of inventory and monitoring efforts will be dependent on effective communication and support among all parties involved. Cooperators must account for factors such as provision of housing for field biologists, equipment availability, and coordination among Chihuahuan Desert Network parks and personnel. The Chihuahuan Desert Network steering committee has decided to hire a GS-11 full-time employee to be the Inventory & Monitoring Coordinator for the network. Office space, support, and supervision will be provided by Guadalupe Mountains NP, but this individual will work for all six parks. This will initially be established as a term position (not to exceed 4 years), until the status and disposition of the monitoring monies is established. The steering committee anticipates that the Coordinator will oversee park involvement in the provision of logistical support, scientific expertise, and access to a competent workforce.

Although it is too early to make detailed arrangements at each park, this will be done in the fall and winter of 2001 prior to the start of specific inventory efforts outlined in Section VI. At that time the Chihuahuan Desert Network steering committee anticipates that the Coordinator will assess the specific details of projects in development and the logistics of park involvement, including (but not limited to) arranging park contacts, housing, transportation, and permits.

IV. VOUCHER SPECIMENS

A. Overview

Voucher specimens, properly identified, cataloged and accessioned, and deposited in accredited storage facilities, are fundamental to an improved understanding of the occurrence and distribution of vertebrate species and plants (Baker et al.. 1996, 1998; Parker et al.. 1998). Beyond the immediate need to document species occurrence, timely voucher collections could also provide a valuable genetic baseline for measuring change associated with global and regional environmental change. (e.g. habitat loss, fragmentation, global warming, increased UV exposure). From a conservation standpoint, however, the benefits of vouchering must be balanced against our mission as stewards. It is undesirable to allow research or management activities to affect the population of a native species in any park, unless the purpose of the activity is to preserve that species.

Pragmatic concerns also shaped the voucher policy of the Chihuahuan Desert Network, including the potentially high cost of curatorial services rendered by herbaria and museums, and the minimal facilities and curatorial staffing available in most Network parks. Cooperators and investigators will be required to collect adequate vouchers to document species occurrence, but extensive vouchering to document the full range of phenotypic variability will not be undertaken. Final decisions regarding the appropriate repository for each taxon have not yet been made. The Network steering committee anticipates that the regional Inventory & Monitoring Coordinator will facilitate this effort through contacts with the major regional herbaria and museums.

Voucher preparation will be the responsibility of inventory investigators and must follow guidelines outlined in 36 CFR and the Museum Handbook. Permission to take duplicate vouchers will be considered on a case-by-case basis by individual park resource managers. Investigators must have a valid park collection permit to collect specimens. All vouchers taken on NPS lands, regardless of their final repository, are the property of the NPS. Chihuahuan Desert Network or park personnel will be responsible for accessioning voucher specimens into ANCS+ and entering the appropriate information into the NPSpecies Database.

A number of sources were used to develop a policy of the appropriate circumstances for the taking of voucher specimens. These include collection policies from Great Smoky Mountain National Park (K. Langdon, pers. comm.) and the Illinois Natural History Survey (C. Phillips, pers. comm.), as well as British Columbia inventory standards (British Columbia Ministry of Environment, Lands and Parks 1998).

B. Collection of Vertebrates

In general, vertebrate vouchers will be taken only if necessary for species identification. One specimen will be considered adequate to document occurrence at a park. Collection guidelines for each vertebrate taxon are described in Table 12. Whenever possible, a series of photographs (rather than multiple specimens) will be used to document observed phenotypic variability. Voucher photographs should be clearly labeled with the park where collected, the specific location, date, scientific name, and photographer, and copies should be deposited in at least two places where they will be permanently archived. Collectors should take advantage of every opportunity to collect and accession road-killed animals and other windfalls of specimens (e.g. flood, prescribed fire). Voucher specimen preparation will follow the accepted standards for each taxon (Schemnitz 1980).

C. Collection of Vascular Plants

General plant inventories will include collection of vouchers for all but the most common plant species observed over the course of the inventory. Sufficient plant material should be collected to cover two 39.5 X 29.5 cm herbaria sheets. Roots should be included, where possible, with care taken to leave the remaining plants undisturbed. Flowers or seeds are often necessary for identification and should be collected as needed. For large herbaceous plants, shrubs, and trees, those plant parts critical for identification must be collected. Plant specimens must be protected from wilting and desiccation prior to placement in a plant press. If phenotypic variability is observed, a short series of specimens may be collected for each species.

D. Collection of Rare Species

Because most rare species exist in very small numbers, taking of those species should be limited to situations wherein significant benefit and meaningful new information about the species will result from the taking. For species that are listed on federal or state rare and endangered species lists, specimens shall not be taken without appropriate permits and the express permission of the park resource manager (as specified in collection permit). When feasible, photographs, sound recordings, or plant fragments should be used to document occurrence, rather than collection of whole specimens, except in cases where species identification cannot be made based on external characteristics. For vertebrate species, DNA analysis of tissue samples offers another vouchering alternative. When other means of vouchering are not available, and the investigator has received permission to collect a rare species, only one voucher will be taken to document occurrence at a given park.

While it is likely that more individuals of a species exist at a site than are actually observed or captured during a survey, the risk of depletion of a local population through collection is greater for a rare species than for more common species. A voucher should only be collected if at least 10 individuals of an animal species, or 10-25 individuals of a plant species are present at a given sample site.

Table 12. Voucher guidelines for vertebrate taxa.

Taxon	Suggested Vouchers
Mammals	
Bats	• Wing punch or whole specimens for easily misidentified species (if capture is part of the protocol) • Morphometric data, photographs, digital sonograms or cassette tapes with reference calls as evidence of rare bats
Mid-sized carnivores	• Photographs or hair samples, if possible, to help document species occurrence when inventory is based on tracks
Other mid-sized mammals	• Whole specimens not necessary
Small mammals	• Three of each species (1 per sex & 1 juvenile); skulls used to differentiate between *Blarina*, *Cryptotis*, and *Peromyscus* spp.
Deer	• Whole specimens not necessary
Birds	• Whole specimens not necessary • Visual or song identification by qualified observers (common species) • Photographs and sound recordings of unusual sightings • Complete written description following accepted AOU standards
Amphibians/Reptiles	• Whole specimens if identification difficult, or if trap mortality occurs • Photographs, if diagnostic features clear • Sound recordings (anurans)
Fish	• Whole specimens, if required for identification

V. BUDGET AND SCHEDULE

A total of $ 709,820 was identified for the Chihuahuan Desert Network under the inventory phase of the I&M program. This funding is to address inventory needs for the network to include vascular plants and vertebrates (reptiles, amphibians, birds, mammals, and fish). This funding was to cover over a 5-year period (FY 00-04). Initial funding was granted after receipt of a pre-proposal describing the preparation of a study plan and initial data mining. During FY 2000, the network received $140,318 to develop this study plan and initiate data mining. Then in FY2001, the network received an additional $ 13,000 to support network start-up costs. The Chihuahuan Desert Network has developed the following budget and schedule to accomplish inventory work under the present funding initiative. Through this study plan we are requesting the remaining funding of $ 556,502, to be distributed to inventory work in the network over the remaining three year period.

Work conducted in FY 2000 and 2001. The Chihuahuan Desert Network received $140,318 in FY2000 and $13,000 in FY2001, totally $153,318 to complete work described in the network pre-proposal. The Chihuahuan Desert Network developed an agreement with the USGS-BRD, Texas Cooperative Fish & Wildlife Research Unit, to develop the study plan, conduct initial data mining, and to begin the NPSpecies and other database work. A preliminary scoping meeting was held in February, 2000. A full inventory scoping meeting with approximately 50 attendees was held in Odessa, Texas, during FY 2001 to obtain input from a broader range of specialists on the Chihuahuan Desert. Funding in FY2001 also provided for the purchase of a computer for the Coordinator.

Work proposed for completion in FY 2002-2004. The Chihuahuan Desert Network proposes to hire a permanent full-time term I&M Coordinator/Data Manager to direct and coordinate this program and to serve as a Data Manger. This cost is reflected in the tables below. The inventory work proposed for completion is also summarized in the tables below. These tables summarize the budget and time schedule for inventory work by taxonomic groups, by individual inventory projects, and the scheduled inventories by park and taxonomic group. Detailed project budgets and implementation schedules are found in the individual project statements in Appendix D. Interested and qualified investigators will be sought through requests for interest and qualification. In addition, some of the inventory work will be arranged for through other sources.

Additional data mining was identified as a significant need for the Chihuahuan Desert Network It was estimated that data mining needs comprised approximately 20% of the work that needed to be accomplished and would cost approximately $128 K. It was decided to include the majority of this project as a duty of the I&M Coordinator/Data Management and have that individual accomplish this work.

Table 13. Summary of inventory funding by taxonomic groups.

PROJECT	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	FY 2004	**TOTAL**
Project Initiation & Study Plan	140,318	13,000				
Coordination & Data Mgt.			68,990	68,990	68,622	206,602
Plants			25,000			25,000
Birds			5,000	7,500	27,500	40,000
Mammals			20,000	38,000		58,000
Herps			78,250	77,650	21,100	177,000
Fish				30,000	20,000	50,000
TOTALS			197,240	222,140	137,222	556,602

Table 14. Summary of inventory funding by individual projects.

PROJECT	FY 2002	FY 2003	FY 2004	TOTAL
All-Taxa –01 – Inventory Project Coordination & Data Management	$ 68,990	$ 68,990	$ 68,622	$ 206,602
All Taxa –02 – Development of standardized lists of plants and animal species of special concern	In All Taxa 1	In All Taxa 1	In All Taxa 1	
Vert – 01 – National & Regional Museum searches and data mining for all parks	In All Taxa 1	In All Taxa 1	In All Taxa 1	
Vert – 02 -- Verification of park mammal, herpetofaunal and bird museum collection specimens in all six parks	In All Taxa 1	In All Taxa 1	In All Taxa 1	
Birds –01 – Avian inventory of riparian & wetland areas in CDN parks			$ 25,000	$ 25,000
Birds –02 – Inventory of high elevation breeding birds in GUMO & CAVE		$ 2,500	$ 2,500	$ 5,000
Birds –03 – Inventory of winter resident grassland birds in BIBE & GUMO	$ 5,000	$ 5,000		$ 10,000
Fishes –01 – Survey of fishes in the Rio Grande of the BIBE		$ 30,000		$ 30,000
Fishes –02 – Survey of fishes of AMIS			$ 20,000	$ 20,000
Herps – 01 -- General Amphibian & Reptile Inventory for CDN Parks	$ 78,250	$ 77,650	$ 21,100	$ 177,000
Mammals – 01 – Baseline Inventory of small mammals and bats for AMIS and selected areas at BIBE & GUMO	BIBE $ 20,000	AMIS $ 18,000	GUMO $ 20,000	$ 58,000
Plants – 01 – National and Regional Herbaria searches and data mining for all parks	In All Taxa 1	In All Taxa 1	In All Taxa 1	
Plants – 02 – General Floristic Survey of AMIS	$ 25,000			$ 25,000
Plants – 03 – Verification of park herbarium specimens located in park museum collections in all six parks	In All Taxa 1	In All Taxa 1	In All Taxa 1	

Total Funding Request from I & M Program for FY 2002-2004 $ 556,502

Table 15. Number of Projects by Park and by Taxonomic Group

	AMIS	BIBE	CAVE	FODA	GUMO	WHSA	TOTALS
Data Mining & Data Mgt.	All Taxa	All Taxa	All Taxa	All Taxa	All Taxa	All Taxa	All Parks All Taxa
Plants	X						1
Mammals	X	X			X		3
Birds	X	XX	XX	X	XXX	X	10
Herps (includes Reptiles & Amphibians	X	X	X	X	X	X	6
Fish	X	X					2
Total # of projects for Taxa	5	5	3	2	5	2	21

Table 16. Schedule of Field Inventories by Park, Taxonomic Group and Fiscal Year

	Plants			**Birds**			**Mammals**			**Herps**			**Fish**		
	02	03	04	02	03	04	02	03	04	02	03	04	02	03	04
AMIS	X					X		X		X	X	X			X
BIBE				X	X	X	X			X	X	X		X	
CAVE					X	X X				X	X	X			
FODA						X				X	X	X			
GUMO				X	X X	X X		X		X	X	X			
WHSA						X				X	X	X			

VI. COMPLIANCE

Compliance is an integral part of every resource management activity. It is an important aspect of the entire National Park Service Inventory and Monitoring Program and of every project recommended by the Chihuahuan Desert Network for completion. Assessing the environmental and cultural impacts of this work is necessary to ensure that the consequences of our actions are not more detrimental than the value of the information obtained.

The Chihuahuan Desert Network will incorporate compliance with park and regional research and collection policies, the National Historic Preservation Act (NHPA, Section 106 Consultation, the National Environmental Policy Act (NEPA), and Section 7 Consultation throughout the planning, implementation, and reporting phases of all of our biological inventories. National collecting permit policies, local park collecting permit policies, each park's museum management policies and Scope of Collections, Wilderness guidelines for legal wilderness, and other applicable guidelines will all be addressed, as needed in decision making.

Compliance for each individual project in each park will be the responsibility of that park. Environmental and cultural compliance documentation will be done by the parks through the channels they normally use for project related compliance. Ultimately, each park is responsible for compliance and each park Superintendent is the only person designated authority to approve compliance documents for that park.

The Intermountain Region has several forms on the Intranet to assist parks with compliance actions. One sample form, which the CDN suggests the parks use, is included in Appendix I. Our plans are to coordinate compliance with all of the parks, so that it flows smoothly, places no undue burdens on anyone, and makes the process as consistent as possible for our investigators.

Inidividual parks within the network have specific permitting requirements that will be outlined in the Statements of Work or Agreements with each investigator. At a minimum, each investigator will be required to obtain a park Collecting Permit for each park in which they do work and must submit an Investigator's Annual Report annually and at the completion of each inventory to each park. A high level of internal scoping has been, and will continue to be, incorporated into the planning process at each park level. This is essential to ensure that impacts of collecting to not adversely impact park resources.

Compliance with NHPA Section 106 will be an on-going process for all work that might affect cultural resources. Park and support office archeologists and the SHPO's will be involved in consultation and documentation, as necessary. Preliminary plans for inventories that will require ground disturbance will be sent to the appropriate park cultural compliance coordinators, archeologists and the SHPO's to ensure consultation needs are met. The park coordinators will be asked to coordinate recommendations for uniformity. Based on those recommendations, trap locations will then be assigned as described in the individual project proposals. A XXX Form will be completed by each park for each inventory that requires ground disturbance. Where archeological inventories have not been completed, which is the case in most CDN parks, arrangements will be made for archeological clearance or an archeologist or para-archeologist to be present during installation of pitfall traps and drift fences. This statement will be included in all Statements of Work.

For those projects that involve federally listed T &E species, Section 7 consultation will be completed for those projects. Study plan approval for those projects will be sought through the coordination of each of the park's Section 7 coordinators.

VII. ACKNOWLEDGEMENTS

This study plan was prepared through the joint efforts of a number of individuals. An interagency agreement between The Texas Cooperative Fish & Wildlife Research Unit of USGS-BRD at Texas Tech and the Chihuahuan Desert Network was the primary focus of this study plan. Dr. Nick Parker, Unit Leader, directed the efforts of the Texas Tech contingency of folks who worked on the plan. He obtained the assistance of a number of graduate students, including Tracy Boal, Lindi VanHeuklon and David Bennett. Tracy Boal and Lindi Van Heuklon did field trips to the park to conduct data mining and did database entry of this information. Tracy Boal assisted in writing this study plan and all of its attachments.

Each of the six parks in the network has also contributed to this plan, providing detailed information on their parks, hosting the students who were conducting the data mining, and assisting in writing portions of the plan. The park resource staffs and in particular the CDN Steering Committee representatives, listed in Appendices K & L all helped to complete this plan.

In addition, we all owe a debt of appreciation to all of the individuals who attended the CDN Inventory Scoping Meeting in Odessa, Texas. The insight, wisdom, and collective knowledge of all of those people was extremely useful in the preparation of this plan and helping us to chart a course for this project. The Chihuahuan Desert Network has a lot of work ahead of it and there advice and support were appreciated.

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